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SUMMARY HISTORY OF DOMESTIC URANIUM PROCUREMENT UNDER U.S. ATOMIC ENERGY COMMISSION CONTRACTS FINAL REPORT

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Holger Albrethsen, Jr., and Frank E. McGinley
Grand Junction, Colorado

October 1982

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Nuclear Energy
Grand Junction Area Office, Colorado

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FINAL REPORT

Holger Albrethsen, Jr.

and

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SUMMARY HISTORY OF DOMESTIC URANIUM CONCENTRATE PROCUREMENT UNDER U.S. ATOMIC ENERGY COMMISSION CONTRACTS

PURPOSE AND ACKNOWLEDGEMENTS

During the period 1947 through 1970, the Atomic Energy Commission (AEC) fostered the rapid development and expansion of the domestic uranium mining and milling industry by providing a market for uranium. Some thirty-two mills were constructed during that period to produce U_3O_8 concentrates for sale to the AEC. In addition, there were various pilot plants, concentrators, upgraders, heap leach, and solution mining facilities that operated during the period. The purpose of this report is to compile a short narrative history of the AEC's uranium concentrate procurement program and to describe briefly each of the operations that produced uranium for sale to the AEC. Contractual arrangements are described and data are given on quantities of U_3O_8 purchased and prices paid. Similar data are included for V_2O_5, where applicable. Mill and other plant operating data were also compiled from old AEC records. These latter data were provided by the companies, as a contractual requirement, during the period of operation under AEC contracts. Additionally, an effort was made to determine the present status of each facility by reference to other recently published reports. No sites were visited nor were the individual reports reviewed by the companies, many of which no longer exist. The authors relied almost entirely on published information for descriptions of facilities and milling processes utilized.

Many of the mills that processed domestic uranium ores closed after completing deliveries of U_3O_8 under AEC contracts. Some others produced uranium for sale in the commercial market for a while after completing deliveries to the AEC, and still others continue in operation, although mostly at reduced production rates due to the present soft market for uranium.

Concern over the potential health impacts that might result to individuals from exposure to radiation from uranium mill tailings prompted Congress to enact legislation authorizing the AEC, and later the Department of Energy, to undertake remedial action to prevent or minimize the environmental hazard from such tailings. In 1972, Congress passed Public Law 92-314 (later amended by Public Law 95-238) to provide authority and funding for a Federal/State program to perform remedial action on structures in the Grand Junction, Colorado, area where uranium mill tailings had been used for construction. The Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604) authorized a remedial action program for the inactive uranium mill tailings sites. Presently some 24 sites where mills, concentrators, upgraders or uraniferous lignite burners operated have been designated and assigned a priority for remedial action. For information on the current status of inactive sites, the authors utilized the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). Similarly, for information on millsites where tailings resulted from production of uranium for both Government and commercial buyers, the authors referred to the report, Commingled Uranium Tailings Study, Volume II, Technical Report, June 30, 1982 (DOE/DP-0011).

All of the facilities which processed uranium for sale to the Government were initially licensed by the AEC, which retained the Federal licensing and

regulatory authority until January 19, 1975, when the Nuclear Regulatory Commission (NRC) was activated pursuant to the Energy Research and Development Act of 1974. However, a number of States assumed licensing and regulatory authority over such facilities under agreements with the AEC which were authorized by a 1959 amendment to the Atomic Energy Act of 1954. Those "agreement" states in which milling facilities that supplied uranium to the AEC were located include Arizona, Colorado, Idaho, New Mexico, North Dakota, Oregon, Texas, and Washington. Any operating uranium processing plants in those states continue to be subject to state regulatory authority, while the NRC exerts regulatory authority over those mills which are operating in Utah and Wyoming. Inactive uranium processing sites which have been designated for remedial action pursuant to Public Law 95-604 will be regulated in accordance with the provisions of that Act.

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The authors' appreciation is extended to David Blanchfield, of the DOE, who served as Technical Monitor for the project and who reviewed the entire manuscript for technical content. Gilman C. Ritter, Director, Mining Division, BFEC, contributed materially in providing historical records and information not otherwise available to the authors. The arduous task of typing was skillfully accomplished by Dorothy Jenkins.

INTRODUCTION

The Atomic Energy Commission was established by the Atomic Energy Act of 1946 in recognition of a need to provide for a civilian Government agency which could assure the continued development of atomic energy for military purposes and also promote the research and development necessary to the utilization of atomic energy for peaceful applications.

During World War II the Manhattan Engineer District (MED), under the Army Corps of Engineers, had been charged with the development of atomic weapons and by August 1, 1946, when the Atomic Energy Act was signed into law, the MED had assembled an organization of over 5,000 military and civilian employees and was administering contracts involving a total work force of more than 50,000 people. Its activities included research and development, engineering and design, the operation of production facilities for weapons materials and components, and the acquisition of uranium, the basic raw material essential to the production of nuclear weapons.

All of these MED functions, and the numerous Government-owned facilities in which many of them were being performed, were transferred to the AEC by Executive Order 9816, effective at midnight, December 31, 1946. An Office of New York Directed Operations was established by the AEC on June 9, 1947, and that office supervised the procuring and processing of uranium until the AEC's Division of Raw Materials was formed in October 1947 to direct those activities from the AEC's Headquarters office in Washington, D.C.

The Colorado Raw Materials Office was established at Grand Junction, Colorado, in December 1947 to carry out the AEC's domestic uranium procurement program. An Exploration Branch, initially under the direction of the AEC's New York office, was also established at Grand Junction, and in November of 1952 the domestic uranium procurement and exploration functions were combined within the newly formed Grand Junction Operations Office, under the overall direction of the Division of Raw Materials at Headquarters.

The earliest of the AEC's domestic uranium procurement contracts were negotiated by the New York office and by the Division of Raw Materials. (These are identified by contract numbers with prefixes AT-30-1-GEN- and AT(49-1)-, respectively). Those contracts were transferred to Grand Junction after the establishment of the Colorado Raw Materials Office, and thereafter were administered from Grand Junction. With only minor exceptions, all of the succeeding contracts for the procurement of uranium concentrates domestically were negotiated and administered by the Grand Junction office. A few contracts, involving relatively minor quantities of uranium derived as a byproduct from phosphate and other miscellaneous operations, were negotiated and administered by AEC Headquarters divisions in the 1952-1961 period.

Procurement of uranium concentrates by the AEC spanned the period from 1947 through 1970. During those years, in definable stages, the market for uranium concentrates changed from a monopsony with the Federal Government as the only buyer, to a completely commercial market with no Government purchases. From the viewpoint of the Government as a consumer, the foreseeable supply of uranium increased from desperately short of that which was required for defense needs, to adequate, to surplus. Procurement policies and contracting practices were adopted, implemented, and modified in response to the

Government's changing needs and the perceived lack or adequacy of uranium supplies with which to meet them.

The AEC procurement policies and practices were not dictated solely by its defense needs, however. The agency was also guided by provisions of the Atomic Energy Acts of 1946 and 1954 which were designed to foster development and utilization of atomic energy for peaceful purposes. Therefore, procurement policies also reflected concern for fostering and maintaining a producing uranium industry which would be able to supply the nation's expected uranium requirements for private nuclear power development.

The following synopsis will cite uranium procurement policies employed by the AEC to satisfy the dual objectives set forth above, and will briefly describe the mechanisms used to effectuate those policies.

THE BEGINNING SITUATION, 1947

By the beginning of 1947, when the AEC assumed management of the Government uranium procurement program from the MED, that agency had purchased about 10,000 tons of U_3O_8 for use in developing atomic weapons. Only about 15 percent of that amount, obtained as a vanadium byproduct, was attributable to domestic production.

Five vanadium processing plants had operated on the Colorado Plateau during World War II, aided by a Government program offering incentive for vanadium production. That program was terminated in 1944, however, and by the end of 1946, only one plant was still operating, and only at half capacity. A total of 55 men were employed in the 15 vanadium-uranium mines operating on the Colorado Plateau, and uranium production was practically nill.* It was from this almost nonexistent resource base that the AEC launched its Domestic Uranium Procurement Program in 1947.

SUMMARY OF THE PROCUREMENT PROGRAM

During the period 1947-1970, the AEC purchased uranium concentrate from private companies primarily for use in military weapons programs. Prior to April 1, 1962, the AEC also purchased uranium ores and guaranteed the prices to be paid by the milling companies for ores as an incentive to the uranium mining industry to provide feed for the processing mills. From a contracting standpoint, the pre-1962 period was characterized by guaranteed ore prices and individually negotiated concentrate prices.

On May 24, 1956, the AEC announced the establishment of a new domestic uranium procurement program for the period April 1, 1962, through December 31, 1966. The action was taken "in recognition of the need for a continuing Government market in order to maintain a high rate of exploration and development." The new program guaranteed a Government market for 500 tons of U_3O_8 in concentrate per year from any one mining property or operation at a flat price

*Address by Jesse C. Johnson, Manager, Raw Materials Operations, U.S. Atomic Energy Commission, at a meeting of the American Mining Congress, Salt Lake City, Utah, August 30, 1950.

of $8 per pound. Thus, in 1956, the stage was set for a continuing AEC concentrate procurement program after March 31, 1962, with an established price for concentrates rather than for ores.

By late 1957, dramatic increases in reported ore reserves and in milling capacity prompted an AEC announcement that "it no longer is in the interest of the Government to expand production of uranium concentrate."* Then, in November 1958, in order to prevent further expansion of production under its essentially unlimited purchase commitment, the AEC redefined its 1962-1966 procurement program by withdrawing portions of the program announced in May 1956. The Government stated it would buy, in the 1962-1966 period, only "appropriate quantities of concentrate derived from ore reserves developed prior to November 24, 1958, in reliance upon the May 24, 1956, announcement."† Other aspects of the program announced in 1956 were retained: The AEC would buy only concentrates; the U_3O_8 price would remain at $8 per pound; and ores would not be purchased nor ore prices guaranteed.

With the objective of fostering the development and utilization of atomic energy for peaceful purposes, the AEC announced in May 1958 that "domestic producers of uranium ores and concentrate may now make private sales of these materials to domestic and foreign buyers for peaceful uses of atomic energy."‡ All such sales would be subject to licensing by the AEC, and the release of uranium under contract to the AEC would be considered, subject to appropriate contract modifications. While this announcement removed the legal impediment to private sales of uranium concentrate, no such sales were actually made until 1966.

In 1962, it was apparent to the AEC that the private market for uranium concentrates would not be sufficient to sustain a viable domestic uranium industry by the end of 1966 when the AEC procurement program was scheduled to end. Thus, in November 1962, the AEC announced its "stretch-out" program for 1967 through 1970.§ Under the program, the milling companies could voluntarily defer delivery of a portion of their 1963-1966 contract commitments until 1967 and 1968 in return for an AEC commitment to purchase, in 1969 and 1970, an additional amount of U_3O_8 equal to the quantity so deferred. The "stretch-out" program was the last of the major policy changes made in the AEC procurement program, although in January 1969, the AEC requested and accepted proposals for some further reductions in deliveries of concentrates in 1969 and 1970. The procurement program ended December 31, 1970.

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*Remarks prepared by Jesse C. Johnson, Director, Division of Raw Materials, U.S. Atomic Energy Commission, for delivery before the 4th Annual Conference of the Atomic Industrial Forum, New York, New York, October 28, 1957.

†Announcement dated November 21, 1958, and released November 24, 1958.

‡Public statement issued by the U.S. Atomic Energy Commission in Washington, D.C., May 8, 1958.

§Announcement dated November 17, 1962, and published in the Federal Register, November 20, 1962, 27FR11435.

URANIUM ORE PROCUREMENT

The ultimate procurement aim of the AEC was to purchase uranium in concentrates. Its first uranium procurement action was execution of a contract with Vanadium Corporation of America on May 28, 1947, for the delivery of concentrates from its mill at Naturita, Colorado. It was obvious that production of concentrates was directly dependent upon an assured supply of uranium ores, which in turn required a rapid expansion of exploration and mining efforts. To provide an incentive for those efforts, in April 1948, the AEC announced a domestic procurement program designed to stimulate prospecting and to build a domestic uranium mining industry. Private industry would be tasked with finding, mining, and processing uranium ores. The AEC would assist by making geologic surveys, furnishing free testing and assaying services, and, most important, guaranteeing a market for uranium ores.

The AEC ore market guarantee was promulgated by a series of Domestic Uranium Program Circulars, several of which were occasionally revised and extended.

Circular 1 (April 11, 1948) guaranteed for 10 years a minimum price for certain high-grade uranium ores. It expired April 11, 1958.

Circular 2 (April 11, 1948) offered a bonus of $10,000 for delivery of 20 short tons of uranium-bearing ores or mechanical concentrates assaying 20 percent or more U_3O_8 from any single mining location, lode, or placer which had not been previously worked for uranium. The bonus was collected once, prior to the expiration of the Circular on April 11, 1958.

Circular 3 (April 11, 1948) provided for minimum prices, specifications, and conditions under which the AEC would purchase carnotite and roscoelite-type ores at Monticello, Utah. It also established payment of 31 cents a pound for the vanadium content (V_2O_5) of the ores.

Circular 4 (June 1, 1948) provided for payment of haulage and development allowances for uranium ore producers.

Circular 5 (February 1, 1949) consolidated Circulars 3 and 4, increased the price of U_3O_8 in ore, and established premium prices for higher grade ore. This Circular was revised and broadened March 1, 1951, and remained in effect as Circular 5, Revised, through March 31, 1962.

Circular 6 (June 29, 1951) offered bonus payments for initial and certain other production of uranium ores to assist in development of new sources. The Circular expired March 31, 1960.

A necessary corollary to price guarantees set forth in the Circulars was the provision of Government ore-buying stations in areas of expected production. The first of these was set up at Monticello, Utah, where the AEC was reconstructing for uranium production a vanadium processing plant acquired from the War Assets Administration. Ores were purchased at Monticello from 1948 through March 31, 1962, with the expiration of Circular 5, Revised.

During the next several years, the AEC established ore-buying stations in the new uranium-producing areas where it appeared ore production would be sufficient to support a mill. If and when a mill was built to provide the

necessary market for the ore, the AEC would withdraw and the stockpiles of ore accumulated by the AEC would be sold later to the mill for processing.

AEC ore-buying stations were established and operated for varying periods at the following places: Marysvale, Moab, White Canyon, and Monticello, Utah; Shiprock and Grants, New Mexico; Globe and Tuba City, Arizona; Riverton and Crooks Gap, Wyoming; and Edgemont, South Dakota. In addition, the AEC made arrangements for mill contractors and the AEC ore-buying agent to purchase uranium ore at Bluewater and the Ambrosia Lake area in New Mexico; Salt Lake City, Mexican Hat, and Moab, Utah; the Shirley Basin area in Wyoming; and in Karnes County, Texas. These arrangements were for limited periods of time, and usually while mills were under construction. The tonnages, U_3O_8 grade, and pounds U_3O_8 contained in ore purchased at AEC ore-buying stations are presented in Appendix B, Table B-1 of this report.

By their terms, Circular 5 and Circular 5, Revised, provided for uranium prices, specifications, and conditions under which the AEC would purchase carnotite and roscoelite-type ores at its Monticello, Utah, ore-buying station. In practice, however, the AEC was guided by the terms of the circulars in its payment for ores at the other buying stations, although it sometimes deviated from those terms; for example, by making deductions for high lime content in the ores, by adding a price factor for ores containing copper, or by deleting the payment factor for vanadium.

The AEC also required, during the period prior to April 1, 1962, that uranium companies selling concentrates to the AEC must pay for the uranium content (and in appropriate cases, the vanadium content) of purchased ores at prices, premiums, and allowances not less favorable to the ore producer than the provisions of Circular 5 (later Circular 5, Revised).

ANCILLARY PROGRAMS

From 1948 until the mid- and late-1950s, the AEC pursued several programs designed to increase quantities of uranium available for Government procurement. While these were not uranium procurement programs as such, brief mention is made because of their considerable impact on the AEC purchase programs and, ultimately, its procurement policies.

Between 1948 and 1956, the AEC, assisted by the U.S. Geological Survey, pursued a broad program of uranium exploration. Several hundred AEC and USGS geologists searched for uranium deposits, first in the Colorado Plateau area and ultimately in Wyoming, New Mexico, and parts of several other western states. The program involved temporary withdrawal of some 700 square miles of public domain for exploration, geologic studies, drilling and examination of samples, and airborne reconnaissance. Results were regularly published for use by private companies and individuals. Where no ores were found, the lands were promptly returned to the public domain.

When ores were discovered by AEC drilling on withdrawn lands, the AEC leased the lands to private parties in return for a royalty on ore production. A total of 49 leases were issued between 1949 and March 31, 1962, when this leasing program was terminated.

Another aid to private industry exploration and production was an access-road program under which the AEC, in conjunction with the Bureau of Public Roads and various state agencies, improved over 1,200 miles of roads in Arizona, Colorado, New Mexico, South Dakota, Utah, and Wyoming. These improvements, accomplished between 1951 and mid-1958, provided access to uranium mining areas and mill facilities.

The AEC also conducted research and development leading to improvements in milling processes, and shared the results of its studies with the private sector.

URANIUM CONCENTRATE PROCUREMENT

As noted earlier, the main objective of the AEC raw materials program was the acquisition of uranium concentrate coupled, particularly in the later stages of the program, with the objective of maintaining a domestic uranium-producing industry capable of supplying raw materials required for peaceful uses of atomic energy, primarily nuclear power production.

Beginning with the first concentrate procurement contract in May 1947, the number of privately owned and operated uranium processing mills under contracts with the AEC grew until, in 1961, there were 27 mills operating. Contracts were negotiated pursuant to the Atomic Energy Acts of 1946 and 1954, which authorized the AEC to establish guaranteed prices for source materials delivered to it within a specified time. The contracts were initially entered into for periods of 5 years or more so the milling company would have an opportunity to amortize plant costs during the contract term.

Prior to negotiating a contract with a milling company, the AEC required submission of a detailed proposal showing that the company could meet the AEC requirements for an adequate ore supply, technical capability, and financial responsibility. If these requirements were met, the AEC and the company negotiated a contract for the construction and operation of a processing plant of a specified nominal capacity in terms of tons of ore per day processed. The price per pound of U_3O_8 in concentrate was arrived at through negotiation, with the AEC taking into account ore cost, estimated milling cost (including plant amortization), metallurgical losses, and profit. Ore cost was calculated by using ore prices set forth in Circular 5 (later Circular 5, Revised) both with respect to ores to be purchased by the milling company and ores which it owned or controlled. An ore haulage cost was also allowed based on the average haulage distance for ores expected to be processed at the mill.

Initially, and in all cases prior to May 8, 1958, the contracts required that the entire production of the processing plant be delivered to the AEC, limited to the annual maximum quantities which it was obligated to purchase under the contract. The contracts also generally required the milling company to purchase ores from independent ore producers, if offered, within a stated percentage of the mill's ore requirements. In some cases, the contracts provided an increase in AEC concentrate purchase obligations to include production from independently produced ores which the AEC might direct to the mill. In a few cases, the AEC agreed to purchase vanadium concentrates which were produced in conjunction with the uranium and for which there was an inadequate commercial market. In other cases, it reimbursed milling companies

at Circular 5, Revised, prices for vanadium contained in the ores, and where recovery of vanadium appeared to be uneconomic the vanadium was allowed to go to tailings. Data on AEC purchases of vanadium are given in Appendix B, Table B-2.

This general pattern of negotiation and contracting practice prevailed with respect to uranium concentrates purchased by the AEC through March 31, 1962. By that date, a total of 28 processing mills had been constructed and 23 were in operation in the western United States.

As of the mid-1950s, the AEC Domestic Uranium Procurement Program had not been defined for any period beyond March 31, 1962. Its announcement issued May 24, 1956, provided that definition by establishing a new domestic procurement program for the period from April 1, 1962, through December 31, 1966. The action was taken "in recognition of the need for a continuing Government market in order to maintain a high rate of exploration and development." The announcement noted that assurance of such a market would assist uranium mining and milling firms in planning future operations, and expressed the AEC expectation that a gradual transition from a Government-controlled market to a commercial market would take place as industrial demand developed.

The new program established a flat price of $8 per pound for U_3O_8 in concentrate purchased by the AEC subsequent to March 31, 1962, and guaranteed a Government market for all uranium concentrates produced by domestic mills from domestic ores, subject to a limitation of 500 tons of U_3O_8 per year from any one mining property or mining operation. The AEC ore purchase and price guarantees would be discontinued after March 31, 1962.

In contracts and contract modifications and extensions executed after May 24, 1956, the concentrate price structure and the contractors' obligations regarding payment for independent ores were defined separately for the period of the contract ending March 31, 1962, and for the period beginning April 1, 1962, and ending December 31, 1966. Through March 31, 1962, the concentrate price continued to be a negotiated one; as of April 1, 1962, it became the announced $8 per pound, with a few exceptions where an amortization factor was added to the $8 price to take care of plant amortization which had been negotiated but could not be recovered by March 31, 1962. Conversely, through March 31, 1962, the mill contractor was required to pay at least Circular 5, Revised, prices, premiums, and allowances for purchased ores; after March 31, 1962, the requirement was that the mill operator pay "reasonable" prices.

Soon after the 1956 announcement, large ore discoveries were made in Wyoming, and the potential of the Grants, New Mexico, area was becoming apparent. These developments prompted the AEC to announce on October 28, 1957, that "it is no longer in the interest of the Government to expand the production of uranium concentrate." The objective of the AEC would be to limit production to the approximate level which would be reached as a result of existing commitments.

If new contracts were to be considered, preference would be given to providing a limited market for areas having inadequate milling facilities. This "limited expansion" was implemented through execution of new contracts and the amendment and extension of existing contracts to allow for treatment of increased amounts of ore from southeast Texas, the Gas Hills and Crooks Gap

areas of Wyoming, the Colorado Front Range, and the Moab and Mexican Hat areas of Utah.

By its announcement of November 24, 1958, the AEC withdrew prospectively its April 1, 1962, through December 31, 1966, uranium concentrate procurement program which had been announced on May 24, 1956. In effect, it would carry out its May 24, 1956, commitment but only with respect to ore reserves developed prior to November 24, 1958, in reliance upon the earlier announcement. It would do this by negotiating for the purchase of appropriate quantities of concentrates derived from such ore reserves during the period from April 1, 1962, to December 31, 1966.

In the months following the November 24, 1958, announcement, a determination of eligible properties was made and an allocation system was established by the AEC. Under this system, an eligible mining property was identified as a property having a market quota (allocation) established by the AEC under the terms of the announcement. Allocations were based on ore reserves developed prior to November 24, 1958, (or in certain areas having irregular uranium deposits which were normally not developed prior to mining) on the property's production history during the period July 1, 1956, through June 30, 1960.

The AEC received requests for allocations for more than 2,500 uranium properties, but investigations of many of these showed no developed reserves, and the AEC ultimately issued a total of 800 allocations. In some cases, owners applied for allocations on properties from which it was unlikely that uranium could be mined at a profit. The AEC chose not to substitute its judgment for that of the property owner, however, and allocations were issued for properties on which reserves had been developed before November 24, 1958, even though economic production might be doubtful.

Along with the determination of allocations under the November 24, 1958, announcement, a review was made of the situation of the small independent mining properties which indicated that many of them could not sustain an economic operation at the production levels imposed by the allocations. To assist this group of some 600 small properties, in June 1962, the AEC issued an announcement which permitted mills to purchase, under AEC-approved contracts between the mill and mine operator, up to 20,000 pounds U_3O_8 in ore annually from eligible small properties, subject to an overall group limitation of 1 million pounds per year.

A few contracts were to terminate earlier than 1966 for various reasons, but most procurement contracts were rewritten in accordance with the November 24, 1958, announcement and extended through 1966.

Again, for the remainder of the pre-April 1, 1962, period, the contracts retained their former characteristics with respect to negotiated concentrate prices and requirements for purchasing ores under the provisions of Circular 5, Revised. In the period beginning April 1, 1962, the AEC would pay $8 per pound for the U_3O_8 in concentrate, and the milling company would pay "reasonable" prices for ores acquired from independent producers.

By this time, the ban on private sales of uranium concentrates had been lifted, so the contract modifications generally provided that the milling companies could sell concentrates to other than the AEC. In the pre-April 1,

1962, period, prior, written, AEC authorization was required for such sales. Thereafter, any concentrate production in excess of the AEC purchase obligation could be sold to any properly licensed buyer without AEC approval.

The most substantive change in the contracts was caused by the fact that they became the vehicles by which the AEC enforced its allocation program in the period beginning April 1, 1962, so as to purchase no more than the appropriate quantity of concentrate ascribable to each mining property's allocation. To accomplish this, it was necessary for the milling contract to describe each separate mining property controlled by the milling company and to specify the number of pounds U_3O_8 which would be purchased as to each such property. An agreed-upon mill recovery factor was applied to translate the property's allocation of U_3O_8 in ore to an appropriate quantity of U_3O_8 in concentrate. Further, provision was made for AEC approval of each ore purchase agreement entered into by each milling contractor. The ore purchase agreement was required to specifically describe the property or properties from which the ore would be produced, and the maximum quantity to be purchased from each such property. The maximum purchase obligation of the AEC, in each concentrate procurement contract, was a combination of pounds U_3O_8 allocated the properties owned or controlled by the milling company, plus pounds U_3O_8 allocated to mining properties from which the mill company acquired ores under AEC-approved agreements. Since substitutions of ore from one property to another were not allowed, any shortfall in ore production below a mining property's allocation resulted in a commensurate reduction of the AEC maximum purchase obligation.

The last major change in the AEC procurement policy was announced November 17, 1962. The announcement established a new program for the period January 1, 1967, through December 31, 1970, noting that AEC requirements for U_3O_8 through 1970, as then currently estimated, were significantly below the amounts which would be available if domestic operations continued through that period at current levels. So, to effect a better balance between AEC receipts and requirements and to help provide for a continuing industry to supply the anticipated commercial market, the AEC offered the mill operators the option of deferring a portion of the U_3O_8 contracted for delivery to AEC in 1963-1966, and delivering it in 1967 and 1968. In return, in 1969 and 1970, the AEC would purchase an additional quantity of U_3O_8 equal to the amount deferred. The price to be paid for the deferred material in 1967 and 1968 would be $8 per pound, the same as in the 1962-1966 contracts. The price to be paid in 1969 and 1970 for concentrates produced from properties controlled by the mill contractor would be calculated by use of a formula based on average allowable costs of production during the 1963-1968 period, as determined by an audit of mining and milling costs. The fixed price per pound of U_3O_8 in concentrate would be 85 percent of the allowable production cost per pound plus $1.60, subject to a maximum price of $6.70 per pound of U_3O_8. The price for all concentrates produced from ores purchased from independent producers would be $6.70 per pound of contained U_3O_8.

Uranium milling companies were invited to submit proposals covering the quantity of material they would be willing to defer for delivery after 1966. For the next 3 years, the AEC engaged in lengthy negotiations with the various companies to work out details for the so-called "stretch-out." Several firms elected not to participate in the program, but 11 companies did so. They were: Vanadium Corporation of America, mill at Shiprock, New Mexico; The Anaconda Company, mill at Bluewater, New Mexico; Western Nuclear, Inc., mill

in Fremont County, Wyoming; Utah Construction & Mining Company, mill in Fremont County, Wyoming; Kerr-McGee Corporation, mill near Grants, New Mexico; Atlas Corporation, mill at Moab, Utah; Federal-Radorock-Gas Hills Partners, mill in Fremont County, Wyoming; Homestake-Sapin Partners, mill near Grants, New Mexico; United Nuclear Corporation, mill near Grants, New Mexico; and Union Carbide Corporation with two contracts, one for U_3O_8 production from the mill in Natrona County, Wyoming, and the other for production from the two mills at Uravan and at Rifle, Colorado.

Negotiation of the stretch-out contracts began in 1963, and the last of the contract modifications (actually, complete rewritings of the contracts) was signed November 26, 1965. During the negotiation and preparation of the formal contracts, the contractors reduced their operations beginning as early as 1963, under letter agreements with the AEC which would enable the milling companies to make up for any reduced deliveries of concentrates should negotiations fail. Consequently, total AEC purchase of U_3O_8 in concentrate began to decline as early as June 1963.

Under the stretch-out contracts, the allocation system was continued in effect through 1968, but thereafter the milling companies were free to produce concentrates from any domestic ore source without regard to allocations. Throughout the period January 1, 1963, through December 31, 1970, the milling companies were free to produce uranium concentrate in excess of that which the AEC was obligated to purchase, and to sell such excess concentrate to any purchaser properly licensed to receive it. The only prohibition was that such sales could not be made to a purchaser acquiring such concentrate for resale to the AEC.

The AEC uranium procurement program ceased with the expiration of the stretch-out contracts on December 31, 1970. The Appendix B, Table B-3, AEC Purchases of U_3O_8 in Concentrates from Uranium Mills by Fiscal Year, presents complete data on all AEC purchases for the duration of the uranium procurement program.

SUMMARY HISTORIES OF URANIUM MILLS AND OTHER URANIUM PROCESSING PLANTS

In the preparation of this report an effort was made to include pertinent contractual information, operating data, and the current status of all uranium ore processing plants or mills that produced uranium concentrates for sale to the AEC. Some of the earliest contracts were not available so other sources of information, such as AEC press releases and audit reports, were used. An individual report was prepared for each mill and is included in Appendix A. Also, to the extent information and data were available, a report was prepared for other uranium processing plants, such as concentrators, upgraders and lignite burners. These reports are presented in alphabetical order by states and location.

Data on the pounds of U_3O_8 purchased by the AEC under each procurement contract and the prices paid were taken directly from AEC records at the Department of Energy's Grand Junction Area Office (GJAO). In some instances where a single contract covered production from more than one mill, it was necessary to use contractor (company) supplied data on the split between or among the mills. The pounds U_3O_8 purchased were the "settlement" pounds arrived at after AEC weighing and sampling of each concentrate lot and the exchange of AEC and contractor analyses of a representative lot sample. The pounds of U_3O_8 purchased sometimes differs from the pounds of U_3O_8 reported shipped to the AEC by the mill operator (as shown in Tables 1 and 2 of the reports on individual mills). This difference is attributed to differing weighing, sampling and analytical procedures used by the mill and the AEC.

Mill operating data were for the most part taken from GJAO records entitled "AEC Production Data Contractors' Operations." Monthly operating report data were recorded and compiled on a fiscal year basis by the AEC as received from the individual contractors. (At that time the Government fiscal year commenced July 1 and ended June 30 of the following year.)

In Appendix B are four tables of statistical data. Table B-1, AEC Ore-Buying Stations - Summary of Ore Receipts, is a compilation of station locations, quantities of ores received, and the time frame during which the station was in existence. All of the ore acquired by the AEC was either processed at the Monticello, Utah, mill or sold to a private mill and the uranium recovered therefrom purchased by the AEC under a concentrate procurement contract. During the period February 1949 through February 1965, the AEC purchased a total of 3,368,809 tons of ore averaging 0.31% U_3O_8. Of this total, 907,917 tons were fed to process in the AEC's Monticello mill, and 2,460,892 tons of ore were sold to other mill owners. Although ore purchases under Circular 5, Revised, terminated March 31, 1962, the table shows two other ore purchasing arrangements (Moab and Shirley Basin) that occurred after that date. These special ore purchases are explained in the Atlas Corporation and Petrotomics Company reports.

Early in the AEC's procurement program the uranium-vanadium ores of the Uravan Mineral Belt constituted the only known significant reserves in this country. However, any increase in uranium production from the carnotite-type ores would be accompanied by an increase in vanadium production. For the AEC to assure an adequate supply of uranium, it was necessary to provide a market for vanadium when the commercial demand was low. Therefore, the uranium purchase

contracts with vanadium producers included guarantees to purchase vanadium, within limits and at a fixed price of $0.98475 per pound V_2O_5, whenever the commercial market was inadequate to absorb the vanadium production. This permitted these mills to operate at full capacity for uranium output. Consequently, the AEC purchased vanadium in the form of fused vanadium oxide during the period 1949 until June 30, 1959. As shown in Table B-2 of Appendix B, a total of 28,615,775 pounds of V_2O_5 was bought from six mills treating carnotite-type ores. Most of the vanadium was transferred to the General Services Administration and held in the strategic metals and minerals stockpile but ultimately all the vanadium was sold on a competitive bid basis for somewhat more than it cost the AEC.

In Table B-3, AEC Purchases of U_3O_8 in Concentrates from Uranium Mills by Fiscal Years, data are given on the quantities and costs of U_3O_8 purchased during each fiscal year and the total costs. The production of uranium and AEC purchases increased significantly from the early to late 1950s and reached a maximum of 17,646 tons U_3O_8 in FY 1961. The average fiscal year costs ranged from a maximum $12.35 per pound U_3O_8 in FY 1953 to a low of $5.54 in FY 1971 when the AEC procurement program was terminated. Data on other domestic U_3O_8 purchases are also given in the table footnotes. The totals for all domestic purchases of U_3O_8 in concentrates were 348,818,438 pounds U_3O_8 at a cost of $2,979,390,249.

Table B-4, Uranium Mill Operations Under AEC Contracts & Other Uranium Processing Plants, summarizes data from the individual mill and other uranium processing plant reports. Shown for each mill are the period of operation under its AEC contract, the quantity and grade of ore processed, other millfeed, the U_3O_8 produced, the pounds U_3O_8 sold to the AEC and the average price per pound U_3O_8. The price, or cost to the AEC, ranged from a low of $7.49 to a high of $15.01. The weighted average price for all U_3O_8 purchases listed in Table B-4 was $8.52 per pound U_3O_8.

Data on the "other uranium processing plants" listed in Table B-4 are less complete because in many cases only the production that was received at the mill was reported to the AEC. Only those plants for which information and data were available are included in this report. Heap leach operations, to the extent known, are included in the reports of the mills to which they were tributary, rather than as separate facilities. The same is true of plants which recovered uranium from mine waters and in-situ leach operations.

APPENDIX A: SUMMARY HISTORIES OF URANIUM MILLS AND OTHER URANIUM PROCESSING PLANTS

URANIUM MILLS

ARIZONA

Tuba City, Rare Metals Corporation of America and El Paso Natural Gas Company . . . . . A- 3

COLORADO

Canon City, Cotter Corporation . . . . . A- 7
Durango, Vanadium Corporation of America . . . . . A- 10
Grand Junction, Climax Uranium Company and American Metals Climax, Inc. . A- 15
Gunnison, Gunnison Mining Company . . . . . A- 18
Maybell, Trace Elements Corporation and Union Carbide Corporation . . . . A- 21
Naturita, Vanadium Corporation of America . . . . . A- 24
Rifle, United States Vanadium Corporation and Union Carbide Corporation . A- 29
Uravan, United States Vanadium Corporation and Union Carbide Corporation A- 38

IDAHO

Lowman, Porter Brothers Corporation . . . . . A- 43

NEW MEXICO

Ambrosia Lake, Kermac Nuclear Fuels Corp., Kerr-McGee Oil Industries, Inc., & Kerr-McGee Corporation . . . . . A- 45
Ambrosia Lake, Phillips Petroleum Company and United Nuclear Corporation A- 49
Bluewater, Anaconda Copper Mining Company and The Anaconda Company . . . A- 52
Grants, Homestake-New Mexico Partners . . . . . A- 55
Grants, Homestake-Sapin Partners . . . . . A- 59
Shiprock, Kerr-McGee Oil Industries, Inc., Vanadium Corporation of America, & Foote Mineral Co. . . . . A- 64

OREGON

Lakeview, Lakeview Mining Company . . . . . A- 69

SOUTH DAKOTA

Edgemont, Mines Development, Inc. . . . . A- 72
Edgemont, Mining Research Corporation . . . . . A- 76

TEXAS

Falls City, Susquehanna-Western, Inc. . . . . A- 78

UTAH

White Canyon (Hite), Vanadium Corporation of America . . . . . A- 81
Mexican Hat, Texas-Zinc Minerals Corporation and Atlas Corporation . . . A- 83
Moab, Uranium Reduction Company and Atlas Corporation . . . . . A- 86
Monticello, The Galigher Company and National Lead Company, Inc. . . . . A- 90
Salt Lake City, Vitro Corporation of America . . . . . A- 95

WASHINGTON

Ford, Dawn Mining Company . . . . . A- 98

WYOMING

Gas Hills, Federal-Radorock-Gas Hills Partners A-101
Gas Hills, Globe Mining Company, Globe Mining Corporation, and Union Carbide Corporation A-104
Gas Hills, Lucky Mc Uranium Corporation and Utah Construction & Mining Company A-107
Riverton, Fremont Minerals, Inc. and Susquehanna-Western, Inc. A-111
Shirley Basin, Petrotomics Company A-115
Split Rock, Lost Creek Oil and Uranium Company, Western Nuclear Corporation, & Western Nuclear, Inc. A-118

OTHER URANIUM PROCESSING PLANTS

ARIZONA

Monument Valley, Vanadium Corporation of America A-123

COLORADO

Slick Rock, North Continent Mines, Inc. A-126
Slick Rock, Union Carbide Corporation A-128

NORTH DAKOTA

Belfield, Union Carbide Corporation A-130
Bowman, Kermac Nuclear Fuels Corporation A-132

UTAH

Green River, Union Carbide Corporation A-134
White Canyon Mining District, COG Minerals Corporation A-136

WYOMING

Baggs, Shawano Development Corporation A-138
Converse County, Wyoming Mining and Milling Company A-139

RARE METALS CORPORATION OF AMERICA AND EL PASO NATURAL GAS COMPANY
Tuba City, Arizona

Contract No. AT(05-1)-293 was entered into with Rare Metals Corporation of America on July 15, 1955. It was replaced by Contract No. AT(05-1)-910, between the AEC and El Paso Natural Gas Company, which had acquired Rare Metals by a merger in July of 1962. The new contract was signed on November 19, 1962 and was effective from September 10, 1962 through December 31, 1966, with provision for final delivery of concentrate by February 2, 1967.

Through March 31, 1962, the AEC paid negotiated prices for the U_3O_8 in concentrates. Thereafter the price was the fixed $8.00 per pound of U_3O_8 established by the AEC's May 24, 1956 announcement.

Ore supplies for the Tuba City mill were obtained from the Cameron, Arizona, and adjacent areas and from the Orphan Lode mine owned by Western Equities, Inc., and located in the Grand Canyon National Park. That mine became the principal source of ore for the mill after rights to mine in the park area were resolved by Public Law 87-457, effective May 28, 1962.

On February 1, 1956, the AEC opened a uranium ore buying station at Tuba City millsite. The sampling plant, constructed and owned by Rare Metals, was leased to the AEC under Contract No. AT(05-1)-645, pending completion of the mill being erected at the same site. During the period FY 1956-1957, the AEC purchased 40,782 tons of ore averaging 0.22% U_3O_8 and 0.05% V_2O_5. This ore, as well as some ore from other AEC ore buying stations, or a total of 58,093 tons of ore, was sold to Rare Metals, which processed it into concentrate for sale to the AEC. Ore acquired from the AEC was 8 percent of the total millfeed during the 11-year operation of the mill. Independent ore producers (including Western Equities, Inc.) supplied 78 percent of the ore processed in the mill, while contractor-controlled mines furnished 14 percent.

The Tuba City mill ceased production shortly before Contract No. AT(05-1)-910 expired on December 31, 1966. The site is now inactive, and has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the Tuba City site and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981, (DOE/EP-0011).

The Tuba City millsite is located in northern Arizona approximately 75 miles north of Flagstaff and 5 miles east of Tuba City on the Navajo Indian Reservation. The site is located along the south side of U.S. Highway 160, which connects Tuba City with Kayenta, Arizona, and is at an elevation of about 5,000 feet above sea level. The land around the site is rather desolate and is used by the Navajos for grazing sheep and cattle. The site covers 88 acres and consists of a mill, office and ore storage area (30 acres), a tailings area (22 acres), evaporation pond area (20 acres), and a housing area (16 acres) on both sides of the highway. The remainder of the site is all south of the highway. The site land was leased from the Navajo Nation and, shortly after the mill was shut down in 1966, full control of the site reverted to the Navajo Nation.

The mill began operation in June 1956 with a nominal capacity of 260 tons of ore per day; however, once start up difficulties were overcome, the capacity was stepped up to 300 tons per day, and the mill operated continuously at that rate until May 1962. At that time the mill was shut down pending negotiations with the AEC for a contract to continue operations. As noted earlier, the problem concerning the right to mine ore that extended from the Orphan Lode mine under park land was resolved by PL 87-457. When the Orphan Lode mine became the principal ore supply for the mill it was necessary to modify the mill process. This was accomplished by installing used equipment acquired from the AEC in 1961 and 1962 by competitive bidding during the dismantling of the AEC's Monticello, Utah, mill. Once the new contract had been signed with the AEC, plant modification proceeded rapidly, and operations resumed in April 1963 at the design capacity of 200 tons per day. That daily throughput was maintained until plant shut down in late 1966. During the life of the Tuba City mill a total of 796,489 tons of ore averaging 0.33% U_3O_8 was processed and 90 percent of the U_3O_8 was recovered. All of the U_3O_8 produced was sold to the AEC.

The initial milling process consisted of crushing, grinding (in a pebble mill), sulfuric acid leaching, sand-slime separation, and recovery of uranium from the slime fraction by use of the basket resin-in-pulp ion exchange process. Most of the ores processed initially were of low lime content, less than 6% $CaCO_3$, the exception being the Orphan Lode ore which ranged as high as 25% $CaCO_3$. It was this high lime content that necessitated the process change when the Orphan Lode mine became the principal source of ore.

The mill conversion required the installation of additional ore grinding equipment, a flotation circuit to remove sulfides, which are carbonate consumers, pressure leach vessels (autoclaves), filters for liquid-solids separation, precipitation tanks, and solution carbonation equipment for leach solution recycle.

Equipment was also added to acid leach the sulfide flotation concentrate for uranium removal. The concentrate then contained sufficient sulfide copper to be marketable at a copper smelter. The uranium dissolved from the flotation concentrate was recovered by ion exchange. The small amount of copper solubilized with the uranium was recovered as cement copper by the addition of powdered iron to the ion exchange barren solution. El Paso reported in 1964 that the Orphan Lode ore averaged about 1.3% Cu and that 75 percent of the total copper or 90 percent of the sulfide copper was recovered. The copper concentrate averaged 20% Cu and 10 ounces of silver per ton in the sulfides. The cement copper averaged 55% Cu. Both products were shipped by truck to the smelter at Inspiration, Arizona. No other data are available on the copper production at the Tuba City mill.

Rare Metals and El Paso always sought to provide employment opportunities for the Navajo Indians, as evidenced by the mill complement that routinely was two-thirds or more Navajos.

Tables 1 and 2 present data on the AEC purchases of U_3O_8 from Rare Metals' and El Paso's Tuba City operation and mill production data during the term of the AEC contracts.

Table 1 - AEC Purchases of U_3O_8 from El Paso Natural Gas Co.-Tuba City, AZ

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-293	1957[a]-1962	2,698,493	10.88
AT(05-1)-910	1963-1967[b]	1,999,868	8.00
Total	1957 - 1967	4,698,361	9.65[c]

a) First U_3O_8 delivered 7/56.
b) Last U_3O_8 delivered 11/66.
c) Average Fiscal Year costs ranged from $7.98 to $12.84.

Table 2 - Mill Production Data - El Paso Natural Gas Co.-Tuba City, AZ

	AEC Contracts
Period of Operation	6/56 - 9/66[1/]
Uranium Ore	
Fed to Process (Tons)	796,489
U_3O_8 (%)	0.33
U_3O_8 (Lbs.)	5,233,029
Production	
U_3O_8 in Conc. (Lbs.)	4,696,402
U_3O_8 Recovered (%)	90
U_3O_8 Shipped to AEC (Lbs.)	4,696,402
U_3O_8 Shipped to Others (Lbs.)	0

1/ Ore was fed to process from June 4, 1956 through May 1962 and from April 1963 through September 1966. Concentrate was produced from plant inventories in October and November 1966.

After the mill shut down all of the mill equipment and most of the buildings were removed from the site. The structural steel frame of the main mill building and the concrete block office building remain, as well as the houses in the housing area.

The tailings, consisting of three connected piles, are located south of the mill building. Approximately 800,000 tons of tailings remain at the site. A chemical stabilizer was applied to the surface of the tailings in 1968, but has since been determined to be ineffective in preventing wind transport of the tailings. As noted earlier, the site has been designated for remedial action and has been given a "medium" priority.

Although there is no record of tailings being removed from the site, mobile gamma radiation surveys have detected some anomalies in the housing area and in Tuba City. The DOE, through follow-up surveys, will determine the vicinity properties to be designated for remedial action.

COTTER CORPORATION
Canon City, Colorado

Contract No. AT(05-1)-735 was entered into on May 23, 1957, for the purchase by the AEC of uranium concentrates produced by Cotter Corporation's small pilot plant at Canon City. The purpose of the pilot plant was to develop processes for the treatment of uranium ores mined in the Front Range area of Colorado. The effective period of the contract was from March 1, 1958 through February of 1959, with provision for extension of the term through February of 1960. The term was so extended and the contract expired on Febraury 29, 1960.

On December 17, 1959, the AEC and Cotter Corporation signed Contract No. AT(05-1)-783, effective March 1, 1960, and extending through February 28, 1965, with provisions for final deliveries within an additional 30 days. Under this contract the pilot plant was expanded to a full-scale processing mill. The contract gave the AEC an option to extend the term through December 31, 1966. The option was not exercised, however, and the contract expired on February 28, 1965.

Under Contract No. AT(05-1)-735, since production costs for the developmental pilot plant operation could not be determined in advance, the AEC paid Cotter the $8.00 per pound price, which had been established by the AEC's May 24, 1956, announcement, for U_3O_8 in concentrates for the period beginning April 1, 1962. Under Contract No. AT(05-1)-783 the AEC paid a negotiated price for U_3O_8 in concentrates purchased through March 31, 1962. Thereafter it paid a fixed price of $8.00 per pound of U_3O_8 in concentrate as established by the AEC's May 24, 1956 announcement.

During the period of the AEC contracts the primary sources of millfeed for the pilot plant and the mill were mines in the Front Range area of Colorado, most notably the Schwartzwalder mine, a vein-type deposit 8 miles north of Golden. However, some ores were shipped to the mill from such distant mines as the Orphan Lode in Arizona. Further, under one of the provisions of Contract No. AT(05-1)-783, the AEC required Cotter to accept a considerable quantity of ore which the AEC had acquired in the Shirley Basin area of Wyoming. Overall, Cotter purchased over 92 percent of the ore fed to process in the plants, with about 23 percent of its purchased ore provided by the AEC.

After Contract No. AT(05-1)-783 expired, the mill was shut down in February of 1965. The mill resumed operation in late 1966 and produced uranium concentrates and other mill products for private sale until December 7, 1979. Cotter Corporation, now a subsidiary of Commonwealth Edison, is presently processing uranium-vanadium ores in a new mill which began operation in September of 1979 at a location adjacent to the older mill.

The site of the pilot plant and the older mill is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, under Public Law 96-540. A detailed description of the Canon City tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

Cotter Corporation began its Canon City operations with a 50-75 ton per day (tpd) pilot plant, located on a 640 acre plot of land about two miles south of Canon City. The pilot plant operation began in July of 1958, and the AEC received its first uranium concentrate from the plant in August of that year. Following the extension of its contractual arrangements with the AEC on March 1, 1960, Cotter Corporation enlarged the pilot plant to a mill with a capacity of 150 to 220 tpd.

The flow sheet of the pilot plant consisted of crushing, fine grinding, alkaline leach with a hot sodium carbonate bicarbonate solution, filtration to separate the solids, solution clarification, and precipitation of the uranium with caustic soda (sodium hydroxide). This same basic flow sheet was used in the expanded plant through the period of the AEC contract.

In 1967 the mill was modified and enlarged to process about 400 tons per day in the alkaline leach circuit and 100 tons per day in an acid leach-solvent extraction circuit.

The unique acid circuit was designed to handle residues resulting from the processing of high grade ores from the Belgian Congo region during World War II by Mallinckrodt Chemical Works of St. Louis, Missouri. The acid circuit was unique in that it provided for the extraction and recovery of uranium, copper, nickel, and cobalt. Using a specifically developed process, Cotter also recovered protactinium-231 and ionium-230 in the form of a low grade precipitate from the Mallinckrodt residues for a period in 1971. These precipitates were sold to an AEC contractor for research purposes. After Cotter completed processing of the residues in 1971, the acid circuit was used to process uranium ores that were unamenable to alkaline leaching, and other materials such as spent catalysts for molybdenum recovery.

As part of the plant expansion in 1967 a flotation circuit was added to remove the iron and copper sulfides from the ore prior to alkaline leaching. These sulfides were acid leached to remove the uranium before shipment to the smelter.

The plant was shut down in December of 1979, about three months after start-up of Cotter's new 1,500 tpd milling operation.

Tables 1 and 2 summarize data on AEC purchases of U_3O_8 from Cotter and mill production data for the period of the AEC contracts. These data are for both the pilot plant and the mill operation through February 1965. Information on subsequent production is given in the previously mentioned report, Commingled Uranium Tailings Study.

Table 1 - AEC Purchases of U_3O_8 from Cotter Corp.-Canon City, CO

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-735	1959[a]-1960	501,298	8.00
AT(05-1)-783	1960-1965[b]	2,641,690	8.27
Total	1959 - 1965	3,142,988	8.23[c]

a) First U_3O_8 delivered 8/58.
b) Last U_3O_8 delivered 1/65.
c) Average Fiscal Year costs ranged from $8.00 to $8.75.

Table 2 - Mill Production Data - Cotter Corp.-Canon City, CO

	AEC Contracts
Period of Operation	7/58-2/28/65
Uranium Ore	
Fed to Process (Tons)	319,384
U_3O_8 (%)	0.54
U_3O_8 (Lbs.)	3,419,198
Production	
U_3O_8 in Conc. (Lbs.)	3,196,597
U_3O_8 Recovered (%)	93
U_3O_8 Shipped to AEC (Lbs.)	3,139,758
U_3O_8 Shipped to Others (Lbs.)	0
U_3O_8 Ending Inventory (Lbs.)	56,839

At the termination of the AEC contract there were approximately 319,000 tons of tailings impounded at the Canon City millsite. During the 1966-1979 period these tailings were covered with tailings resulting from uranium and byproduct production for commercial sales. The pond, covering about 30 acres, ultimately contained a total of about 1.5 million tons of tailings, which are being moved during 1982 to a 43.5 acre clay and membrane-lined tailings area within the impoundment built for the new mill. When the transfer is completed, removal of contaminated subsoil from the 30-acre tailings site will be undertaken using decontamination criteria defined by the Colorado Department of Health with the advice of the Nuclear Regulatory Commission.

An adjacent impoundment area covering about 91 acres, also clay and membrane-lined, receives tailings from the new mill and runoff from the millsite. The large pond keeps the tailings wet and prevents dusting.

From startup through CY 1981 a total of about 1,930,000 tons of ore had been processed in the old mill and new mill resulting in a similar quantity of tailings.

No tailings have been removed from the millsite.

VANADIUM CORPORATION OF AMERICA
Durango, Colorado

Contract No. AT(49-1)-305 was entered into with Vanadium Corporation of America, effective October 8, 1948, initially for a term extending through June 30, 1953. Amendments to the contract resulted in a term ending on June 30, 1958. The contract was replaced by Contract No. AT(05-1)-747, which was entered into on February 24, 1958, effective from July 1, 1958 through March 31, 1962. On May 22, 1961, the AEC and Vanadium Corporation of America entered into Contract No. AT(05-1)-900, effective April 1, 1961, and simultaneously terminated Contract No. AT(05-1)-747. The new contract term ran through December 31, 1966.

Contract No. AT(05-1)-900 was rewritten as Modification No. 1, which was entered into on November 26, 1965, effective from April 1, 1962 through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. The modification allowed the contractor to process ore at any or all of its milling facilities for delivery of uranium concentrate to the AEC. Having acquired the Shiprock, New Mexico, mill from Kerr-McGee Oil Industries, Inc., VCA elected to shut down the Durango plant in March of 1963, and to use the Shiprock facility. The Shiprock operation continued until June of 1968, when deliveries to the AEC ceased under the contract.

Modification No. 1 to Contract No. AT(05-1)-900 was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962.

Under the contracts the AEC paid negotiated prices for U_3O_8 in concentrates purchased through March 31, 1962. Under Contract No. AT(05-1)-900, in the period April 1, 1962 to June of 1968, when deliveries ceased, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement.

Under Contract No. AT(49-1)-305 the AEC purchased vanadium concentrate which was in excess of that which could be absorbed by the commercial market, paying a negotiated price of $0.98475 per pound of contained V_2O_5. Purchases of vanadium concentrates from the Durango mill ceased in mid-1958.

Ore for the Durango operation came from numerous small underground mines in western Colorado, southeastern Utah, northern New Mexico, and the Monument Valley area of Arizona. Fifty-three percent of the millfeed was mined from properties controlled by the contractor and the remaining forty-seven percent was purchased by the contractor from independent ore producers. Millfeed also included slime concentrates from VCA's upgrader at Naturita, Colorado, which operated from late 1961 to early 1963, and upgraded material from Monument Valley, Arizona, where VCA and later Foote Mineral Company operated an upgrading facility from 1955 to 1964.

After milling operations ceased in 1963 the mill was dismantled. The millsite and tailings areas are now owned by Ranchers Exploration and Development Corporation, except for two small parcels which were acquired by the Colorado Highway Department and by La Plata Electric Company.

Ranchers had planned to move the tailings to another site near Durango for processing similar to that used by Ranchers on the Naturita tailings. Production at Durango was projected by Ranchers to commence in mid-1979 and to continue for about 32 months. However, Ranchers was unsuccessful in obtaining the required State permits and abandoned the project.

The Durango site, as well as the Naturita and Monument Valley upgrader sites, have been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. Detailed descriptions of the sites and tailings are contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). Operations at the Monument Valley upgrader facilities are discussed under the section of this report entitled, "Other Uranium Processing Plants". The operation of the Naturita upgrader is covered in the report on VCA's milling operations at Naturita.

The Durango millsite is a 147-acre tract located on the southwest side of the city of Durango, Colorado, just outside the city limits. It is bordered on the east by the Animas River. The Durango site was originally acquired by the American Smelting and Refining Company for the construction and operation of a lead smelter. At the beginning of World War II, it was acquired by the Reconstruction Finance Corporation, a Government agency, which contracted with United States Vanadium Corporation to convert and operate the plant for vanadium production. The vanadium was supplied to Metals Reserve Company, which had been established by the Government to purchase strategic materials for wartime needs. United States Vanadium operated the plant for the Government until early 1944, when the Government vanadium purchasing program was terminated because of adequate vanadium stocks. U.S. Vanadium Corporation then purchased the facilities from the Reconstruction Finance Corporation and operated them for the production of vanadium for commercial sales until August 31, 1945, when the plant was closed.

During the 1943-1944 period U.S. Vanadium Corporation also constructed and operated a uranium-vanadium sludge plant at the Durango site, under a cost-plus-fixed-fee agreement with the Manhattan Engineer District (MED). Feed for the plant consisted of vanadium tailings from past and current operations. The sludge was shipped to a refinery at Grand Junction, Colorado, also operated for the MED by U.S. Vanadium. There, the vanadium was removed to make the sludge suitable for further refining to black oxide.

Prior to entering into Contract No. AT(49-1)-305 with Vanadium Corporation of America the AEC bought the Durango facilities from U.S. Vanadium Corporation. It then leased the facilities to VCA for the initial term of Contract No. AT(05-1)-305, giving an option to VCA to purchase the plant at the end of the period (June 30, 1953). The option was exercised and VCA thereafter operated the plant as a privately-owned facility.

When the Durango mill was reactivated in 1949 for the production of concentrates for sale to the AEC it had a nominal capacity of about 175 tons per day, which was expanded to 430 tpd by 1956 and 750 tpd by 1958. During the period of its operation (1949-1963), the mill processed ore at an average rate of about 350 tpd and treated a total of 1,605,234 tons of ore averaging 0.29% U_3O_8 and 1.55% V_2O_5. This tonnage included upgraded product from the Monument Valley, Arizona, upgrading facility which averaged 0.25 - 0.30% U_3O_8 and 2.0% V_2O_5. The plant also processed

other products (slime concentrates from Naturita and vanadium liquors sold to VCA by other milling companies) containing a total of 458,909 pounds of U_3O_8 and 3,425,527 pounds of V_2O_5. From the combined millfeed, recovery of uranium averaged 80 percent and vanadium recovery averaged 70 percent. The AEC purchased all of the U_3O_8 and 15.6 percent of the V_2O_5 produced during the period of the AEC contracts.

The mill process used during the period of the AEC contracts provided for separate salt roasting of ores and of concentrates from VCA's upgrader plants and for carbonate leaching of the calcines. Ore calcines were quenched and percolation leached while the concentrate calcines were quenched and then treated by countercurrent washing on a series of three drum filters. Pregnant solutions from these two circuits were then combined and a sodium uranyl vanadate, or artificial carnotite, product was precipitated by addition of sodium chlorate, acidification and boiling, then neutralizing to pH 7. The bulk of the vanadium remained in the filtrate and was precipitated as red cake. The reducing fusion and water leaching process was then used to remove the vanadium from the uranium concentrates. The uranium was recovered as black oxide (UO_2), and soluble vanadium subsequently was recycled and precipitated as vanadium red cake. The red cake was dried and fused to produce flake fused oxide.

Tailings from the carbonate leaching operations were reclaimed and retreated for additional uranium and vanadium recovery by acid percolation leaching, using a combination of hydrochloric acid solution recovered from the salt-roaster gas scrubbers and additional sulfuric acid. Beginning in the late 1950s the pregnant acid leach liquor was treated by solvent extraction to recover both uranium and vanadium into a final concentrated and purified carbonate liquor suitable for return to the plant precipitation circuit.

The Durango solvent extraction was unique in that it extracted uranium and vanadium simultaneously rather than employing separate extraction circuits, which was the practice at other mills.

Tables 1 and 2 present data on AEC purchases of U_3O_8 and V_2O_5 from VCA's Durango operation and mill production data during the period from March 1949 to March 1963. 1963.

Table 1 - AEC Purchases of U_3O_8 from VCA-Durango, CO

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(49-1)-305	1950[a]-1959	4,243,710	11.27
AT(05-1)-747	1959 - 1961	2,512,823	8.02
AT(05-1)-900	1961-1963[b]	1,094,892	8.00
Total	1950 - 1963	7,851,425	9.77[c]

a) First U_3O_8 delivered 8/49.
b) Last U_3O_8 delivered 3/63.
c) Average Fiscal Year costs ranged from $7.94 to $11.92.

Table 2 - Mill Production Data - VCA-Durango, CO.

	AEC Contracts
Period of Operation	3/49 - 3/63
Millfeed	
Uranium-Vanadium Ore (Tons)	1,605,234[1/]
U_3O_8 (%)	0.29
U_3O_8 (Lbs.)	9,378,083
V_2O_5 (%)	1.55
V_2O_5 (Lbs.)	49,784,907
Slime Concentrates from Naturita	
U_3O_8 (Lbs.)	456,892
V_2O_5 (Lbs.)	2,851,844
Other Millfeed (V liquors)	
U_3O_8 (Lbs.)	2,017
V_2O_5 (Lbs.)	573,683
Total Millfeed	
U_3O_8 (Lbs.)	9,836,992[2/]
V_2O_5 (Lbs.)	53,210,434[3/]
Production	
U_3O_8 in Conc. (Lbs.)	7,851,425[4/]
U_3O_8 Recovered (%)	80
U_3O_8 Shipped to AEC (Lbs.)	7,851,425
U_3O_8 Shipped to Others (Lbs.)	0
V_2O_5 in Fused Oxide (Lbs.)	37,065,953
V_2O_5 Recovered (%)	70[5/]
V_2O_5 Shipped to AEC (Lbs.)	5,791,738

1/ Ore feed included Monument Valley, AZ upgrader product assaying 0.25 to 0.30% U_3O_8 and 2.0% V_2O_5.

2/ Total adjusted for inventory changes was 9,874,432 lbs. U_3O_8. Mill has a large unaccountable loss of 809,253 lbs. U_3O_8.

3/ Total adjusted for inventory changes was 53,319,578 lbs. V_2O_5.

4/ AEC Production Data Book total minus 712 lbs. shipped to Homestake-Sapin Partners (HSP) that were recovered from vanadium liquors received from HSP.

5/ Twenty percent of total V_2O_5 purchased by AEC during period FY 1949-1958.

During the period of its operation the Durango mill generated about 1.6 million tons of tailings, which are contained in two tailings piles covering a total of about 21 acres, with the base of the piles about 30 feet above the Animas River. The piles are relatively flat on top but have steep slopes. The smaller of the piles, covering some 7 acres, is about 90 feet high and the larger pile, covering 14 acres, is about 230 feet high.

The piles themselves have not been stabilized with earth cover, but vegetation has been planted on them and an irrigation system is used during the summer. A 9-acre raffinate pond, about a half mile from the larger tailings piles, has been filled, covered with local soils, graded, and seeded. Vegetation typical to the locality is now established on that area. None of the mill buildings remain at the site.

Radiological surveys of the Durango area have detected many anomalies (gamma radiation levels above natural background), indicating that some tailings apparently have been removed and used as fill material under and around structures and that windblown tailings have migrated from the millsite. Followup surveys by the DOE have indicated that remedial action will be required on several properties.

The Durango site has been assigned a "high" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

CLIMAX URANIUM COMPANY AND AMERICAN METALS CLIMAX, INC.
Grand Junction, Colorado

Contract No. AT(49-1)-526 was entered into on July 10, 1950, with Climax Uranium Company. The contract was amended on October 21, 1954 to provide for an expansion of the contractor's uranium ore processing plant. The contract terminated on August 1, 1960, the effective date of Contract No. AT(05-1)-792 with American Metals Climax, Inc., which was executed on September 22, 1960. The term of Contract No. AT(05-1)-792 extended through December 31, 1966, with provision for final concentrate deliveries by February 2, 1967.

Under Contract No. AT(05-1)-526, and through March 31, 1962 under Contract No. AT(05-1)-792, the AEC paid negotiated prices for the U_3O_8 in concentrates. After March 31, 1962, the price was the fixed $8.00 per pound of U_3O_8 established by the AEC's May 24, 1956 announcement. Fused vanadium oxide was purchased by the AEC at an agreed price of $0.98475 per pound of contained V_2O_5.

Approximately two-thirds of the ore processed in the mill was obtained from contractor-controlled (owned and leased) sources, with the remaining one-third furnished by independent ore producers and by the AEC.

Ore was received from a large number of individual mines located primarily in the Uravan Mineral Belt of western Colorado.

After termination of Contract AT(05-1)-792, American Metals Climax, Inc. continued to operate the processing plant until February of 1970 for the production of uranium and vanadium for private sales. The mill was later dismantled and the site is now inactive. The site has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978 and has been assigned a "high" priority. A detailed description of the Grand Junction millsite and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Climax 100 ton per day (tpd) mill began operation in Grand Junction, Colorado. in 1951 and was the first mill designed and built in the United States primarily for the production of uranium with vanadium as a byproduct. The 200 acre site selected by Climax was that of a shut down sugar beet processing plant on the north bank of the Colorado River on the south side of the city. The mill produced uranium, and some vanadium, for sale to the AEC through December 1966. Subsequently, until the mill shut down in 1970, all production was for sale in the commercial market.

Climax was the first uranium mill to use acid leach and uranous phosphate precipitation, a new process developed about 1950. It was based on the fact that uranous phosphate will precipitate selectively from acid liquors, giving a much higher grade uranium cake than that obtained in a green sludge formed by neutralization of the acid. Climax incorporated a salt roast and water leach for vanadium recovery, since its millfeed was typical Colorado Plateau carnotite-type ores. Climax also installed a sand-slime separation step to concentrate about 70 percent of the values into the minus 150-mesh fraction comprising 30 to 40 percent of the weight of the ground ore. This decreased, by about two-thirds, the tonnage of ore to be salt roasted for vanadium recovery.

In plant operations the phosphate precipitation process proved unattractive because the uranium precipitate was too high in phosphate and two low in grade, so Climax installed a solvent extraction (SX) process in 1956 after increasing the plant capacity from 330 to 500 tons of ore per day in 1955.

After installing SX, Climax developed, in cooperation with the U.S. Bureau of Mines, a method for precipitating uranium using hydrogen peroxide. The peroxide process enabled Climax to produce a high purity uranium concentrate.

Shown in Table 1 is a summary of AEC purchases of U_3O_8 from Climax. Table 2 summarizes mill production data for the period of the AEC contracts, post-AEC operation, and for the total 19 year plant life. As noted in Table 2, the AEC purchased from Climax excess V_2O_5 in FY 1957 and FY 1959 when the commercial market for vanadium was soft.

Table 1 - AEC Purchases of U_3O_8 from Climax Uranium Co.-Grand Junction, CO

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(49-1)-526	1951[a]-1961	4,684,788	10.71
AT(05-1)-792	1961-1967[b]	4,741,103	8.00
Total	1951 - 1967	9,425,891	9.35[c]

a) First U_3O_8 delivered 6/51.
b) Last U_3O_8 delivered 2/67.
c) Average Fiscal Year costs ranged from $8.00 to $11.81.

Table 2 - Mill Production Data - Climax Uranium Co.-Grand Junction, CO

	AEC Contracts	Post-AEC	Total
Period of Operation	5/51-12/31/66	1/1/67-2/70	5/51-2/70
Uranium Ore			
Fed to Process (Tons)	1,822,696	458,918	2,281,614
U_3O_8 (%)	0.28	0.26	0.28
U_3O_8 (Lbs.)	10,205,622	2,355,026	12,560,648
V_2O_5 (%)	1.35	1.63	1.41
V_2O_5 (Lbs.)	49,289,445	14,982,642	64,272,087
Production			
U_3O_8 in Conc. (Lbs.)	9,454,705	2,235,031	11,689,736 1/
U_3O_8 Recovered (%)	93	95	93
U_3O_8 Shipped to AEC (Lbs.)	9,426,097	--	9,426,097 1/
U_3O_8 Shipped to Others (Lbs.)	--	2,268,080	2,268,080 1/
V_2O_5 Fused Oxide (Lbs.)	34,409,080	11,641,797	46,050,877
V_2O_5 Recovered (%)	70	78	72
V_2O_5 Shipped to AEC	3,276,224 2/	--	3,276,224 2/

1/ Shipments total 4,441 lbs. U_3O_8 greater than production due to settlement adjustments. Actual U_3O_8 purchases by AEC are given in Table 1 and are based on final weights and assays, exchanged between the AEC and Climax.

2/ V_2O_5 purchased by AEC in FY 1957 and FY 1959 when the commercial market was soft.

During the period of its operation the Climax mill generated approximately 2.2 million dry tons of tailings, occupying an area of 55 acres. About 1.9 million tons remain on the site.

During 1970 and early 1971, the mill was dismantled, the smoke stacks were demolished, and the tailings were contoured and covered with top soil. Grasses were planted to establish vegetation. Part of the site (85 acres) was sold for use as an industrial park and 40 acres were ceded to the State of Colorado for use as a repository for tailings removed from the Grand Junction area during the remedial action program (P.L. 92-314 as amended). That program, started in 1972, is intended to reduce radiation exposure to persons in the Grand Junction area that resulted from the removal from the site of an estimated 300,000 tons of tailings and their use as fill material in construction. The program is funded by both the Federal Government (75 percent) and the State (25 percent) and is administered by the Colorado Department of Health.

GUNNISON MINING COMPANY
Gunnison, Colorado

Contract No. AT(05-1)-703 was entered into on November 16, 1956, for a term extending through March 31, 1962. On September 21, 1959, a contract modification effective July 1, 1959, extended the term of the contract through December 31, 1962, with an option in the AEC to further extend the contract through December 31, 1966. However, the mill closed down in April of 1962, shortly after the Gunnison Mining Company's assets had been acquired by Kermac Nuclear Fuels Corporation.

In the contract modification mentioned above, Gunnison Mining Company agreed to defer some of the concentrate deliveries originally scheduled to be made prior to April 1, 1962. As a result, the AEC paid negotiated prices for the U_3O_8 in concentrate throughout the period of the contract in which uranium was produced, rather than applying the $8.00 per pound fixed price for U_3O_8 produced after March 31, 1962.

The mill treated uranium ores from the Gunnison, Colorado, district. Ninety-four percent of the feed came from contractor-controlled sources, notably the Los Ochos properties, and the remaining six percent was purchased from independent ore producers in the area.

After Contract No. AT(05-1)-703 expired the mill processing equipment was removed, and the site has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the Gunnison millsite and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Gunnison millsite is a 61.5 acre tract located just outside the city limits of Gunnison (southwest side), Gunnison County, Colorado. The site is bordered on the north and east by the Gunnison Airport. It is located on flood plain gravels of the Gunnison River that flows in a southernly direction about one-half mile west of the site. The valley is surrounded by mountains that rise to 12,000 feet above sea level. A water tower, office building, and mill building remain on the site. The mill building is used for storage purposes. The site is posted and enclosed with a five-strand barbed wire fence and locked gates.

The Gunnison mill operated for only four years and three months. The mill had a nominal capacity of 200 tons of ore per day (tpd) but operated during its life at an average rate of about 350 tpd. This higher throughput rate was prompted by the lower than anticiapted grade of ore received. In 1958 the grade of ore processed averaged 0.24% U_3O_8. By 1960 the grade of ores received at the mill had dropped to 0.10 to 0.14% U_3O_8, and ore shipments remained in that grade range until the mill closed. Uranium recovery for the life of the operation averaged 88 percent. All U_3O_8 produced was sold to the AEC.

The milling process used at Gunnison consisted of ore crushing and grinding to minus 65-mesh and sulfuric acid leaching for 15 hours at 80°F. using sodium chlorate as an oxidant. After leaching, the pregnant solution and solids were separated by a four-stage countercurrent classifier and thickener circuit, with

the washed solids being sent to tailings. The uranium-rich solution was treated by solvent extraction. The organic solvent was stripped with a sodium carbonate solution which was filtered to remove the iron-precipitate, then the carbonate was destroyed by the addition of sulfuric acid. Magnesia (MgO) was added to a pH of 6.8 to precipitate the uranium yellow cake. The yellow cake was dried, packaged, and shipped to the AEC at Grand Junction.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from the Gunnison Mining Co. and the Gunnison mill production for its total life.

Table 1 - AEC Purchases of U_3O_8 from Gunnison Mining Co.-Gunnison, CO

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-703	1958[a]-1962[b]	1,449,680	9.55[c]

a) First U_3O_8 delivered 2/58.
b) Last U_3O_8 delivered 4/62.
c) Average Fiscal Year costs ranged from $9.33 to $9.76.

Table 2 - Mill Production Data - Gunnison Mining Co.-Gunnison, CO

	AEC Contract
Period of Operation	1/58-4/62
Uranium Ore	
Fed to Process (Tons)	540,423
U_3O_8 (%)	0.15
U_3O_8 (Lbs.)	1,644,011
Production	
U_3O_8 in Conc. (Lbs.)	1,450,976
U_3O_8 Recovered (%)	88
U_3O_8 Shipped to AEC (Lbs.)	1,450,976
U_3O_8 Shipped to Others (Lbs.)	0

The tailings pile on the site is rectangular and covers approximately 39 acres. During deposition the tailings were contained by a dike on the four sides, constructed of pit-run rock and earth scraped from the bottom of the area. Tailings only partially filled the diked area to an average depth of about six feet. After shutdown the tailings were contoured and covered with material excavated from a nearby gravel pit and planted with a mixture of grasses in accordance with plans approved by the Colorado Department of Health. A good growth vegetation has been established on the top of the pile.

As noted earlier, Kerr-McGee acquired the site in late 1961. Colorado Ventures, Inc. bought the property in December 1964, and in 1966, the County was deeded a narrow 3.5 acre strip along the north edge of the site for airport expansion. In August 1973, the millsite was purchased by The Mill, a limited partnership consisting of Denver residents.

Various remedial action options have been suggested for the Gunnison millsite during the course of engineering assessments performed for the DOE. The site has been given a "high" priority for remedial action because of its proximity to the community.

Gamma radiation surveys in the Gunnison area have identified a few locations where possible use of tailings in construction projects were indicated. Future DOE surveys will determine whether any of these locations will require remedial action.

TRACE ELEMENTS CORPORATION AND UNION CARBIDE CORPORATION
Maybell, Colorado

Contract No. AT(05-1)-328 was entered into on August 10, 1955, with Trace Elements Corporation. The contract was superceded by Contract No. AT(05-1)-726, executed on November 5, 1956, to be effective through April 1, 1962. The earlier contract had provided for purchase by the AEC of uranium concentrates from essentially a pilot plant operation at Maybell, while the replacement contract anticipated a full-scale mill operation.

On March 21, 1961, Contract No. AT(05-1)-726 was replaced by Contract No. AT(05-1)-797, which provided for a term extending through December 31, 1966, with provision for final concentrate deliveries through February 2, 1967.

On February 28, 1962, Trace Elements Corporation was merged into Union Carbide Corporation, which assumed Trace Elements' rights and obligations under the contract.

Prior to the merger, Union Carbide Corporation and the AEC had entered into Contract No. AT(05-1)-795, dated April 24, 1961, for the purchase by the AEC of uranium concentrates from Union Carbide's ore processing plants and auxiliary facilities at Rifle, Uravan, and Slick Rock, Colorado. When Union Carbide Corporation and the AEC completed negotiations for Union Carbide's participation in the "stretchout" program, which were formalized in Modification No. 1 to Contract No. AT(05-1)-795, dated October 28, 1965, Contract No. AT(05-1)-797 was merged into Contract No. AT(05-1)-795, effective January 1, 1963.

Under the stretchout modification, which was effective through December 31, 1970, Union Carbide could process ores through all or any part of the "Carbide Complex," which consisted of its facilities at Rifle, Uravan, Slick Rock, and Maybell. The Maybell facility was shut down in October of 1964, and has since been dismantled.

Under Contracts AT(05-1)-328 and 726, and under Contract No. AT(05-1)-797 prior to April 1,1962, the AEC paid negotiated prices for the U_3O_8 in concentrate. Thereafter, until Contract No. AT(05-1)-797 was merged into Contract No. AT(05-1)-795 effective January 1, 1963, the price was the fixed $8.00 per pound of U_3O_8 established by the AEC's May 24, 1956 announcement.

Ore for the Maybell mill came from open pit mines near the millsite. Ninety-five percent of the millfeed was produced by contractor-controlled mining properties and five percent was purchased from independent ore producers.

The Maybell millsite has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the Maybell millsite and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Maybell millsite, consisting of approximately 84 acres, is located in Moffat County, Colorado, about 5.5 miles northeast of Maybell and 25 miles west of Craig. The mill began operations in November of 1957 with a nominal capacity of 300 tons of ore and upgraded slimes per day (tpd). It produced uranium for sale to the AEC until the plant closed down in October of 1964. During the period of its operation the mill processed material at an average rate of 700 tpd and treated a total of 1,764,753 tons of material consisting of raw ore and upgrader slimes produced from low grade (less than 0.2% U_3O_8) ore. The combined millfeed averaged 0.13% U_3O_8, and mill recovery averaged 88 percent. All of the uranium concentrate produced in the mill, as well as a very small quantity of concentrate produced in the earlier pilot plant operation, was delivered to the AEC.

The milling process included an upgrader circuit to treat low grade ores (less than 0.20% U_3O_8) before leaching. The low grade ores were classified into separate sand and slime fractions in the upgrader circuit, where sands were sent to waste and the slimes were acid leached. Higher grade ore was acid leached directly and this leached slurry was then treated in a six-stage classification and washing circuit. The slurry separated in this circuit was combined with the leached slimes from the upgrader and the combined product sent to the continuous, countercurrent resin-in-pulp ion exchange circuit. An ammonium nitrate solution was used to elute uranium from the loaded resin and the uranium was precipitated from the eluate with anhydrous ammonia.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Trace Elements' and Union Carbide's Maybell operation and mill production data during the period of the milling operation.

Table 1 - AEC Purchases of U_3O_8 from UCC-Maybell, CO Mill

Contract No.	Contractor	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-328	Trace Elements Corp.	1956[a]	238	8.00
AT(05-1)-726	Union Carbide Corp.	1958[b]-1961	1,538,142	9.63
AT(05-1)-797	Union Carbide Corp.	1961 - 1963	1,097,116	8.86
AT(05-1)-795[d]	Union Carbide Corp.	1964-1965[c]	1,398,248	8.00
Total		1956 - 1965	4,033,744	8.86[e]

a) First U_3O_8 delivered from pilot operation 10/55.
b) First U_3O_8 delivered from mill operation 12/57.
c) Last U_3O_8 delivered from mill operation late CY 1964.
d) Contract 795 was for the "Complex" that included Maybell.
e) Average Fiscal Year costs ranged from $7.98 to $9.70.

Table 2 - Mill Production Data - UCC-Maybell, CO

	AEC Contracts
Period of Operation	11/8/57[1]-10/64
Uranium Ore	
Fed to Process (Tons)	1,764,753[2]
U_3O_8 (%)	0.13
U_3O_8 (Lbs.)	4,565,291
Production	
U_3O_8 in Conc. (Lbs.)	4,033,744
U_3O_8 Recovered (%)	88
U_3O_8 Shipped to AEC (Lbs.)	4,033,744

1/ Mill operation as distinguished from pilot plant operation that produced only 238 lbs. U_3O_8.

2/ Millfeed consisted of both "high grade ore," containing 0.2% or more U_3O_8, and upgrader slimes produced from "low grade" which assayed less than 0.2% U_3O_8. The slimes were considered as ore fed to process. The total millfeed, ore plus upgrader feed, has been estimated to be 2.6 million tons at 0.098% U_3O_8 (DOE/EP-0011, p. 38).

When the Maybell mill ceased operation in October of 1964 there were approximately 2.6 million tons of tailings impounded at the site, covering an area of about 80 acres. The mill buildings have since been removed, but some of the concrete foundations remain.

In the late 1970s, Union Carbide began heap leaching the low grade ore remaining in its mine at Maybell. A portable ion exchange unit was installed and the eluate was trucked to its Gas Hills, Wyoming, mill for final uranium recovery. Subsequently the ion exchange unit was replaced by solvent extraction and operation continued during the warm weather months.

The tailings have been contoured and stabilized by six inches of earth cover and vegetation. Erosion exposed about 20 percent of the piles' surface, but that area has been re-covered and reseeded so that essentially all of the surface is covered with vegetation. Upslope water is diverted away from the tailings by offpile ditches and a dike, and a drainage system has been installed to drain precipitation off the pile. The tailings are surrounded by a five-strand barbed wire fence, and radiation warning signs are displayed on the fence.

No tailings are known to have been removed from the millsite. The Maybell site is in a sparsely populated area containing many open-pit mines, piles of removed overburden, and low grade ore stockpiles. It has been assigned a "low" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

VANADIUM CORPORATION OF AMERICA
Naturita, Colorado

The first AEC uranium milling contract, No. AT-30-1-GEN-121, was entered into on August 28, 1947, with Vanadium Corporation of America, effective as of May 20, 1947, for a term initially extending through July 30, 1949. Modifications of the contract provided for extensions of the contract term, which ultimately ended on the date final payment was made by the AEC for uranium concentrate produced in the Naturita plant from ores fed to process prior to February 1, 1958, and delivered to the AEC on or before March 15, 1958.

Throughout the period of the contract the AEC paid negotiated prices for the U_3O_8 in concentrate delivered under the contract. In the period from May 1, 1948 through December 31, 1957, the AEC also purchased vanadium concentrate at a negotiated price of $0.98475 per pound of contained V_2O_5.

Millfeed for the Naturita plant consisted of uranium-vanadium ores from relatively small underground mines in the Uravan Mineral Belt area of western Colorado and southeastern Utah. Ore from contractor-controlled properties accounted for 51 percent of the millfeed and ores purchased by the contractor from independent producers, including AEC lessees, accounted for the remaining 49 percent.

The Naturita mill was shut down after deliveries to the AEC were completed in 1958, although Vanadium Corporation of America constructed an upgrader at the site in 1961, and operated it until 1963.

A number of buildings remain at the millsite, now owned by Foote Mineral Company. The tailings and the land underlying them were purchased by Ranchers Exploration and Development Corporation in 1976. In the 1977-1979 period, Ranchers moved the tailings to an area about four miles west of the Naturita site and processed them to recover residual uranium and vanadium. The Naturita millsite and former tailings area have been assigned a "medium" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the Naturita millsite and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Naturita site is located in the narrow San Miguel River Valley, about 4 miles northwest of the town of Naturita in western Colorado. The canyon walls and mesas rise almost 1,000 feet on both sides of the canyon floor. Vegetation is sparse in the area.

The Naturita millsite and tailings occupy a total area of 109 acres between Colorado Highway 141 and the San Miguel River. Seventeen buildings remain on the site. The original salt-roast plant at Naturita, built by Rare Metals Company about 1930, was not operated until 1939 when Vanadium Corporation of America (VCA) purchased the plant and rebuilt it. The plant site was chosen because it offered a good combination of ore, water and coal supplies. VCA operated the mill from 1939 until it was shut down in 1958 and some of the milling equipment was moved to VCA's Durango mill. VCA continued to receive and purchase ore at the Naturita site after the mill closed. In 1961 VCA constructed an upgrader on the site that operated until March 1963. The remainder of the mill and

the upgrader were dismantled after the upgrader was shut down. In 1967, VCA was merged into Foote Mineral Company and site ownership passed to the latter company. In 1975, Foote leased a portion of the site to General Electric Company for an ore buying depot. As noted earlier, in 1976 Ranchers purchased the tailings and the land underlying the tailings pile. The balance of the site is still owned by Foote Mineral Company.

The Naturita mill produced uranium for sale to the AEC from May 1947 until February 1958. The mill initially had a nominal capacity of 50 to 100 tons of uranium-vanadium ore per day (tpd). The capacity was increased to about 200 tpd by 1955 and then to 325 tpd in 1956. During the 10-1/2 years of operation under the AEC contract the mill treated 594,568 tons of ore and recovered 2.7 million pounds of U_3O_8 and 3.1 million pounds of V_2O_5 for sale to the AEC. Because the grade of ore processed averaged 0.30% U_3O_8 and 1.68% V_2O_5, and because somewhat less than 80 percent of the values were recovered, the tailings contained sufficient residual uranium and vanadium to make retreatment economically attractive to Ranchers.

Prior to the initial AEC contract, the Naturita mill produced uranium for sale to the Manhattan Engineer District (MED) during the 1942-1946 period. At that time VCA also sold old vanadium mill tailings to the MED for processing to recover uranium in a Government-owned plant at Uravan operated by United States Vanadium Corporation.

The original plant at Naturita used the conventional salt-roast process. It consisted of ore crushing and dry grinding to minus 14-mesh and subsequent roasting with 7 to 8 percent by weight of salt (NaCl). The roasted calcines were percolation leached with water and the leached residues were sluiced to a tailings pond. The vanadium was precipitated as a "red cake" from solution by the addition of sulfuric acid and heat. The red cake was filtered, washed, dried and fused to form fused oxide suitable for manufacture of ferro-vanadium.

During World War II, and subsequently when uranium recovery was also desired, the neutral water-leach was replaced by an alkaline-sodium carbonate leach solution to extract the uranium. The uranium was recovered as a uranium-vanadium sludge for sale to MED. For sale to the AEC it was recovered from solution as a synthetic carnotite precipitate (sodium uranyl vanadate) by adjusting the pH of the carbonate liquor to around 6.0 with sulfuric acid and boiling to remove the carbon dioxide (CO_2). This precipitated the synthetic carnotite (yellow cake) which was removed by filtration. The yellow cake contained about 20 percent vanadium and other impurities that required removal. This was accomplished by means of a reducing fusion with salt, soda ash and sawdust or fuel oil. This fusion formed a water insoluble black uranium oxide and water-soluble vanadium and other impurities. The melt was cooled and water-leached to produce the concentrate, black uranium oxide, which was filtered, dried and packaged for sale to the AEC. The Naturita mill used this process throughout its operating life, although in the latter years of operation an acid leach of the sands was added to increase uranium recovery. The process was not as efficient for recovery of either uranium or vanadium as the hot acid leach adopted by the milling companies in the mid-1950s.

The upgrader was constructed at Naturita by VCA in 1961 to reduce the cost of ore haulage from Naturita, and the Uravan Mineral Belt, to its mill at Durango. The upgrading process consisted of ore crushing and grinding followed by a sand-slime separation and an attrition scrub of the sands which then were acid leached, washed and sent to the tailings pond. The ore slimes, plus precipitated uranium and vanadium from the acid leach of the sands, were thickened, dewatered, dried and shipped to Durango. During the approximate 18 months the upgrader operated, a total of 108,939 tons of ore, averaging 0.25% U_3O_8 and 1.63% V_2O_5, was processed. Only 84 percent of the uranium and 80 percent of the vanadium reported in the slime concentrate. The actual tonnage of slime concentrate produced at Naturita is not available; however, the slime fraction customarily amounts to 10 to 25 percent of the weight of the ore. A small quantity of slimes was shipped to the Shiprock mill in March 1963 after the Durango mill shut down and VCA took over operations at Shiprock. The uranium recovered from the slime product at both Durango and Shiprock was for sale to the AEC.

The AEC also purchased vanadium, as fused vanadium oxide, from VCA's Naturita mill during the period January 1949 through June 1955. A total of 3,143,513 pounds of V_2O_5 was bought by the AEC.

Table 1 presents data on AEC purchases of U_3O_8 and V_2O_5 from the Vanadium Corporation of America at Naturita. Table 2 shows the Naturita mill and upgrader production data during the periods of the AEC contracts with VCA. As noted earlier, the upgrader product (slimes) was shipped to other VCA mills.

Table 1 - AEC Purchases of U_3O_8 from VCA-Naturita, CO

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT-30-GEN-121	1949[a]-1958[b]	2,775,842	10.45[c]

a) First U_3O_8 delivered 10/47.
b) Last U_3O_8 delivered 2/58.
c) Average Fiscal Year costs ranged from $5.12 to $11.53.

Table 2 - Mill and Upgrader Production Data - VCA-Naturita, CO.

	Mill	Upgrader
	AEC Contracts	
Period of Operation	5/47-2/58[1/]	10/61-3/63
Uranium-Vanadium Ore		
Fed to Process (Tons)	594,568	108,939
U_3O_8 (%)	0.30	0.25
U_3O_8 (Lbs.)	3,539,141	546,485
V_2O_5 (%)	1.68	1.63
V_2O_5 (Lbs.)	20,003,480	3,552,043
Production		
U_3O_8 in Conc. (Lbs.)	2,719,690	--
U_3O_8 Recovered (%)	77[2/]	--
U_3O_8 Shipped to AEC (Lbs.)	2,719,690	--
U_3O_8 Shipped to Others (Lbs.)	None	--
U_3O_8 in Slimes to Durango (Lbs.)	--	456,892[4/]
U_3O_8 Recovered (%) in Slimes	--	84
V_2O_5 in Fused Oxide (Lbs.)	13,527,593	--
V_2O_5 Recovered (%)	68	--
V_2O_5 Shipped to AEC (Lbs.)	3,143,513[3/]	--
V_2O_5 in Slimes to Durango (Lbs.)	--	2,851,844[4/]
V_2O_5 Recovered (%) in Slimes	--	80

1/ Last ore fed to mill 1/31/58.

2/ Adjusted feed to process totaled 3,461,970 lbs., resulting in a recovery of 79 percent. Mill had a large unaccountable loss of 10.8 percent of U_3O_8 fed.

3/ Equals about 11 percent of total V_2O_5 purchased by AEC during the period FY 1949-1959.

4/ U_3O_8 and V_2O_5 in the Upgrader Slime product that was shipped to Durango for uranium and vanadium recovery; however, 998 lbs. U_3O_8 and 6,865 lbs. V_2O_5 in slimes went to Shiprock in 3/63 when the Durango mill shut down.

In 1977, Ranchers, through its wholly-owned subsidiary Durita Development Corporation, obtained the necessary license and other state permits to allow the company to remove the tailings from the Naturita site to a location on the Coke Oven Ranch where they were leached to recover residual uranium and vanadium. Ranchers then covered and stabilized the reprocessed tailings in accordance with Colorado Department of Health regulations.

The tailings at Naturita covered an area of about 23 acres prior to their removal by Ranchers. Ranchers estimated that the site contained 630,000 tons of tailings based on its tailings sampling program. The exact quantity of tailings removed is

not known. The previously cited DOE report (DOE/EP-0011) states that the status of the site was substantially altered by the removal of the majority of the tailings, and that high water in the spring of 1979 inunduated the tailings area. Reexamination of the site is required to determine the impact of residual radioactive residues at and in the vicinity of the site.

Radiation surveys in the vicinity of the millsite indicate that some tailings were apparently removed and used as fill material under and around some 10 to 20 structures in the Naturita and Nucla areas. Further radiological surveys of the site and vicinity properties were scheduled by the DOE in 1981 and 1982.

The ore stockpiled at the site by General Electric Company is being moved to a mill in Utah and the GE ore sampling plant has been dismantled.

UNITED STATES VANADIUM CORPORATION AND UNION CARBIDE CORPORATION
Rifle, Colorado

The AEC's first contract for the purchase of uranium concentrate from the Rifle facility, Contract No. AT-30-1-GEN-171, was entered into on October 2, 1947, with United States Vanadium Corporation for a term expiring on June 30, 1948. That contract was replaced by Contract No. AT(49-1)-301, which was entered into on October 22, 1948, effective for a term from July 1, 1948 through June 30, 1950. On June 22, 1950, the AEC and United States Vanadium Corporation entered into Contract No. AT(49-1)-529, effective July 1, 1950. That contract was replaced by Contract No. AT(05-1)-675, entered into on June 4, 1956 with Union Carbide and Carbon Corporation, successor to United States Vanadium Corporation. The contract term was from July 1, 1956 through March 31, 1962.

Contract No. AT(05-1)-675 provided for the continued operation of the contractor's existing Rifle facility for the production of uranium concentrate for sale to the AEC until a new mill, contemplated by the contract, became operational. In addition to constructing a new uranium processing mill at Rifle, the contractor constructed and equipped two ore concentrators, each with facilities for receiving, crushing, sampling, and beneficiation of uranium ore. The upgrader products of the plants, located at Slick Rock, Colorado, and Green River, Utah, were shipped to the new Rifle mill for processing into uranium concentrate for sale to the AEC.

By a modification dated April 24, 1961, the AEC and Union Carbide Corporation (to which Union Carbide and Carbon Corporation had changed its name in 1957) terminated Contract No. AT(05-1)-675, effective March 31, 1961. On May 1, 1961, the AEC and Union Carbide Corporation entered into Contract No. AT(05-1)-795, effective from April 1, 1961 through December 31, 1966.

The new contract replaced not only Contract No. AT(05-1)-675, which had provided for concentrate purchases from the new Rifle mill, but also Contract No. AT(05-1)-36, under which the AEC had been purchasing concentrate from Union Carbide's Uravan, Colorado mill. Purchases from both facilities were combined under Contract No. AT(05-1)-795.

Contract No. AT(05-1)-795 was rewritten as Modification No. 1, which was executed on October 28, 1965, effective January 1, 1963. The modification extended the contract term through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Under the modification the AEC would continue to purchase uranium concentrate produced by the Rifle and Uravan facilities. The AEC would also purchase concentrates, produced by Union Carbide's milling facility located at Maybell, Colorado, which had been purchased under Contract No. AT(05-1)-797 prior to the effective date of Modification No. 1.

Modification No. 1 to Contract No. AT(05-1)-795 was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962.

Under the contracts the AEC paid negotiated prices for U_3O_8 in concentrate purchased through March 31, 1962. Under Contract No. AT(05-1)-795, in the period April 1, 1962 through December 31, 1968 the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and

continued in effect through 1968 by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, for uranium attributable to contractor-controlled ore sources, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs in the 1963-1968 period, as determined by an audit of mining and milling costs. In the same period (1969-1970) the AEC paid a fixed price of $6.70 per pound of U_3O_8 in concentrate attributable to ores purchased by the contractor from independent ore producers, as required by its November 17, 1962 announcement.

During the earlier period of the contracts the AEC purchased vanadium concentrate which was in excess of that which could be absorbed by the commercial market, paying a negotiated price of $0.98475 per pound of contained V_2O_5. Purchases of vanadium concentrates under the contracts ended in 1954 from the Rifle mill.

Millfeed for the Rifle mills consisted of raw ore from contractor-controlled and independently owned mines primarily in Garfield, Mesa, Montrose, Moffat, and San Miguel Counties, Colorado. During the period from 1958 through 1961 the new Rifle mill also processed upgraded products from the contractor's ore concentrating facilities at Slick Rock, Colorado, and Green River, Utah; and from July of 1964 to November of 1967 processed lignite ash produced by Union Carbide's lignite burning operation near Belfield, North Dakota. Ore for the Slick Rock facilities came from numerous mines in the Uravan Mineral Belt area, and the Green River concentrator received ore primarily from southeastern Utah area. Uranium-bearing lignite for the Belfield burner came from strip mining operations in the Belfield area.

About 62 percent of the raw ore fed to the Rifle plants came from mining properties under the control of the contractor and the remaining 38 percent was purchased from independent ore producers. Contractor-controlled ore sources accounted for about 86 percent of the feed for the Slick Rock concentrator; about 10 percent was purchased by the contractor from independent ore producers; and about 4 percent was acquired from the AEC. At the Green River concentrator, about 56 percent of the feed was produced by contractor-controlled mines and 44 percent was purchased from independent ore producers. Of the lignite material burned at the Belfield facility, about two-thirds was purchased by the contractor from independent producers and one-third was derived from lands under Union Carbide's control.

The old Rifle mill, just east of Rifle, ceased operations in 1958 when the new mill, about two miles to the west, was completed. The newer mill continued to operate after the expiration of Contract No. AT(05-1)-795, producing uranium and vanadium for sale in the commercial market until it was closed down in December of 1972. Since then Union Carbide has used facilities at Rifle for production of special vanadium products.

Both the Rifle millsites, as well as the Belfield lignite burning site and the Slick Rock and Green River concentrator sites, have been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. Detailed descriptions of the sites and tailings and other residues are contained in the report, Background Report for Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). Because of the proximity of the community to the Rifle mill sites both have been assigned a "high" priority for remedial action. Operations at the Slick Rock and Green River concentrators and the Belfield lignite burning operation are also discussed under the section of this report entitled "Other Uranium Processing Plants."

The old Rifle mill was situated on a 22-acre site on the north side of the Colorado River about 0.3 miles east of Rifle and approximately 60 miles east of Grand Junction, Colorado. The plant was operated by United States Vanadium Company (which became a subsidiary of Union Carbide Corporation in 1924) from 1924 to 1932 for the recovery of vanadium from roscoelite ore. When World War II gave rise to an increase in the demand for vanadium the plant was reactivated in 1942 and again processed ore for the production of vanadium until 1946. In 1947, with the advent of the first of the AEC contracts noted above, the mill was altered to permit recovery of uranium was well as vanadium.

During the period from October 1947, through December 31, 1957, the mill processed ore at an average rate of about 200 tons per day (tpd) and treated a total of 693,495 tons of ore averaging 0.35% U_3O_8 and 1.59% V_2O_5. The plant also reprocessed vanadium tailings (generated by earlier operations) containing 146,449 pounds of U_3O_8 and 1,039,164 pounds of V_2O_5. From the combined millfeed, recovery of uranium averaged 85 percent and vanadium recovery averaged 69 percent. The AEC purchased all of the U_3O_8 and 27 percent of the V_2O_5 produced during the 1947-1957 period in which the mill operated under the AEC contracts.

When the old Rifle plant was built in 1924 it recovered vanadium from roscoelite-type ores by salt roasting, water leaching, and the addition of sulfuric acid to the water solutions to precipitate a sodium hexavanadate red cake. In 1947, acid leaching and subsequent process steps were added to extract uranium from the carnotite-type sandstone ores. Water leached residues were releached with sulfuric acid and hydrochloric acid (recovered from roaster gases), and an impure green sludge product was precipitated from the leach solutions by neutralization with ammonia. This product was purified by redissolving in sulfuric acid and sodium chlorate, followed by the addition of sodium carbonate and ferric sulfate to pH 2.5 to precipitate an iron vanadate. After filtration, the addition of additional sodium carbonate to pH 6 precipitated alumina, which was then removed by filtration. Uranium concentrate was finally precipitated from the purified solution by acidifying and boiling to expel carbon dioxide and then adding gaseous ammonia.

The new Rifle plant was constructed on a site consisting of about 300 acres, located some 2 miles west of Rifle between the Denver & Rio Grande Western railway to the north and the Colorado River to the south.

The mill began operations in January of 1958 with a nominal capacity of 400 tons per day (tpd) of ore and concentrates from Slick Rock and Green River. It produced uranium concentrate for sale to the AEC through December of 1970. During that period the mill processed ore at an average rate of about 400 tpd and treated a total of 1,802,019 tons of ore averaging 0.23% U_3O_8 and 2.13% V_2O_5. The mill also processed ore concentrates, lignite ash, and tailings and residues containing a total of 4,508,497 pounds of U_3O_8 and 65,441,828 pounds of V_2O_5. Recovery from the combined millfeed averaged 90 percent for uranium and 83 percent for vanadium. Of the U_3O_8 produced in the 1958-1970 period, more than 99.5 percent was delivered to the AEC. All of the vanadium was produced for the commercial market. All production of uranium and vanadium after 1970 was for commercial sales.

In the new Rifle plant the ore was separated so as to treat material containing uranium with a relatively low vanadium content in a direct acid leaching step, while ores having a higher vanadium content were initially salt roasted. Lignite ash residues were combined with the raw ore. Upgrader concentrates from the Green River and Slick Rock operations were added to the ground ore enroute to pelletizing and salt roasting.

Roasted calcines were water leached to remove soluble vanadate, and this residue was acid leached in a two-stage circuit to dissolve the uranium. The acid leached residues from this latter circuit, as well as those from the direct acid leaching circuit, were washed in a eight-stage countercurrent decantation thickener installation to recover the uranium pregnant solution. After reduction, this solution was treated by solvent extraction to selectively extract the uranium, leaving the dissolved vanadium in the raffinate. The loaded solvent was then stripped with sodium carbonate solution and uranium concentrate precipitated by adding caustic soda.

Vandium-bearing raffinate was treated by solvent extraction to recover the vanadium, which was then stripped from the solvent with sulfuric acid. The solvent used in both the uranium and vanadium circuits was di(2-ethylhexyl) phosphoric acid (EHPA). The acid strip solution was either recirculated for mixing with feed to the salt roaster or the vanadium was precipitated directly by oxidation with sodium chlorate and neutralization with sodium carbonate. Vanadium in the water leach solutions was precipitated by heating and the addition of sulfuric acid. The initial red cakes were purified by redissolving in ammoniacal solution and then crystallizing an ammonium metavanadate product from this liquor by means of an ammonium chloride addition and cooling. This product was fused to a black oxide flake for shipment.

Tables 1 and 2 present data on AEC purchases of U_3O_8 and V_2O_5 from Union Carbide's old Rifle operation and mill production data during the AEC contract period of its operation. Tables 3 and 4 present data on AEC purchases of U_3O_8 from Union Carbide's new Rifle operation and mill production data during the period of its operation. Table 5 presents production data respecting operations at Carbide's Slick Rock, Green River, and Belfield installations.

Table 1 - AEC Purchases of U_3O_8 from UCC-Rifle (Old Mill). CO

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(49-1)-171	1948[a]	120,767	9.00
AT(49-1)-301	1949 - 1951	426,721	9.03
AT(49-1)-529	1951 - 1957	3,013,979	11.84
AT(05-1)-675	1957 - 1958[b]	713,509	10.82
Total	1948 - 1958	4,274,976	11.31[c]

a) First U_3O_8 delivered 12/47.
b) Last U_3O_8 delivered 2/58.
c) Average Fiscal Year costs ranged from $9.00 to $12.34.

Table 2 - Mill Production Data - UCC-Rifle (Old Mill), CO

	AEC Contracts
Period of Operation	10/47 - 1/58
Uranium Ore	
Fed to Proces (Tons)	693,495[1/]
U_3O_8 (%)	0.35
U_3O_8 (Lbs.)	4,896,100
V_2O_5 (%)	1.59
V_2O_5 (Lbs.)	22,088,090
Tailings	
Fed to Process (Tons)	Unknown[2/]
U_3O_8 (Lbs.)	146,449
V_2O_5 (Lbs.)	1,039,164
Total Millfeed	
U_3O_8 (Lbs.)	5,042,549
V_2O_5 (Lbs.)	23,127,254
Production	
U_3O_8 in Conc. (Lbs.)	4,274,976
U_3O_8 Recovered (%)	85
U_3O_8 Shipped to AEC (Lbs.)	4,274,976
U_3O_8 Shipped to Others (Lbs.)	0
V_2O_5 in Fused Oxide (Lbs.)	16,064,442
V_2O_5 Recovered (%)	69
V_2O_5 Shipped to AEC (Lbs.)	4,323,640[3/]

1/ Contract 675 (Am. No. 2) required that no new ore was to be fed to the Old Mill after 12/31/57 and 2 months were allowed for clean-up. This tonnage differs from that estimated earlier for the Inactive Tailings Program (761,000 tons) because the earlier estimate assumed ore was processed in the Old Mill through FY 1958 (6/30/58).

2/ No data are available on either the tonnage or grade of old mill tailings fed to process, just pounds U_3O_8 and V_2O_5.

3/ Last V_2O_5 delivered to AEC in last half of CY 1954. Total V_2O_5 received from UCC-Rifle was 15.1 percent of the total that AEC purchased.

Table 3 - AEC Purchases of U_3O_8 from UCC-Rifle (New Mill), CO

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-675	1958[a]-1961	5,734,181	9.87
AT(05-1)-795	1961-1971[b]	5,970,407	7.84
Total	1958 - 1971	11,704,588	8.73[c]

a) First U_3O_8 delivered 3/58.
b) Last U_3O_8 delivered 12/70.
c) Average Fiscal Year costs ranged from $6.70 to $10.10.

Table 4 - Mill Production Data - UCC-Rifle (New Mill), CO

	AEC Contracts[1]	Post-AEC	Total
Period of Operation	1/58 - 12/70	1/71-12/72	1/58-12/72
Uranium Ore			
Fed to Process (Tons)	1,802,019	200,141	2,002,160
U_3O_8 (%)	0.23	0.13	0.22
U_3O_8 (Lbs.)	8,414,731	530,954	8,945,685
V_2O_5 (%)	2.13	--	--
V_2O_5 (Lbs.)	76,684,568	--	--
Other Millfeed			
Tailings & Residues[2]			
U_3O_8 (Lbs.)	541,777	110,723	652,500
V_2O_5 (Lbs.)	65,441,828	--	--
Ore Concentrates[3]			
U_3O_8 (Lbs.)	3,966,720	--	3,966,720
V_2O_5 (Lbs.)	[4]		--
Total Millfeed			
U_3O_8 (Lbs.)	12,923,228	641,677[8]	13,564,905
V_2O_5 (Lbs.)	142,126,396	--	--
Production			
U_3O_8 in Conc. (Lbs.)	11,649,298[5]	617,628	12,266,926
U_3O_8 Recovered (%)	90	96[9]	90
U_3O_8 Shipped to AEC (Lbs.)	11,609,573	--	11,609,573
U_3O_8 Shipped to Others (Lbs.)	27,419[6]	629,934	657,353
V_2O_5 in Fused Oxide (Lbs.)	117,458,002[7]	--	--
V_2O_5 Recovered (%)	83	--	--
V_2O_5 Shipped to AEC (Lbs.)	None	--	--

1/ AEC Production Data Book totals, less production attributable to the Old Mill.

2/ Includes slime tailings and ferric vanadate from Uravan, beginning early in CY 1963.

3/ Ore concentrates produced at the Slick Rock, CO and Green River, UT concentrators plus lignite ash from Belfield, ND. Quantity fed is 106,210 lbs. U_3O_8 greater than that reported produced in Table 5. Tons of ore concentrates produced at Slick Rock and Green River and received at Rifle through FY 1962 was 202,412 tons. An additional 8,205 tons were received 9/62-4/63. No tonnage is available for the lignite ash received at Rifle.

4/ No V_2O_5 data available but may have been included under "Tailings & Residues".

5/ Purchases exceeded reported production and is probably due to the distribution of purchased pounds under Contract 795 among Rifle, Uravan, and Maybell.

6/ Ending Product Inventory was 12,306 lbs. U_3O_8.

7/ Fused oxide or other vanadium products.

8/ Total possible adjusted for plant inventory decrease was 679,466 lbs.

9/ Or 91 percent based on adjusted total possible.

Table 5 - UCC Concentrator Production Data - Slick Rock, CO; Green River, UT; and Belfield, ND

	AEC Contracts		
	Slick Rock[1]	Green River[2]	Belfield[3]
Period of Operation	3/58 - 12/61	3/58 - 1/61	7/65 - 11/67
Uranium Ore			
Fed to Process (Tons)	591,244	183,386	47,614
U_3O_8 (%)	0.24	0.29	0.37
U_3O_8 (Lbs.)	2,891,796	1,047,831	349,800
U_3O_8 (Lbs.) Adjusted[4]	2,892,705	951,750	364,966
V_2O_5	5/	5/	5/
Production			
Ore Concentrate			
Tons	5/	5/	5/
U_3O_8 (Lbs.)	2,691,035	831,082	338,393
U3O8 Recovered (%)[6]	93	87	93
U3O8 Shipped to Rifle (Lbs.)	2,691,035	831,082	338,393

1/ Concentrated carnotite-type ores, products shipped to Rifle.

2/ Concentrated asphaltic or carbonaceous uranium ores, products shipped to Rifle.

3/ Lignite burning operation, ash product shipped to Rifle.

4/ Total feed adjusted for plant losses or gains in inventory.

5/ No data given in AEC Production Data Book.

6/ Recovery based on adjusted totals.

During the period of its operation for the production of uranium for sale to the AEC the old Rifle mill generated approximately 700,000 tons of tailings. Some 400,000 tons were moved to the new Rifle mill and reprocessed, leaving about 300,000 tons at the old site, occupying an area of approximately 13 acres. The tailings pile has been stabilized with about 6 inches of earth cover and vegetation. Vegetation covers about 85 percent of the pile, which is enclosed by a chain-link fence, and posted.

At the termination of the AEC contracts there were approximately 2.5 million tons of tailings impounded at the new Rifle millsite. As of April, 1981, there were an estimated 2.7 million tons of tailings deposited on the site, covering an area of 32 acres, and ranging in height from 45 to 65 feet. Stabilization measures have included the use of mulch and fertilizer, seeding and planting, and windbreaks, along with an irrigation system. A dike has also been built between the site and the river, and the site is fenced and posted. The mill buildings still remain at the site.

No tailings are known to have been removed from either the millsites, except for the transfer of tailings for reprocessing, as noted above.

Mobile gamma radiation surveys conducted in the Rifle area have indicated about 200 anomalies that will require DOE follow-up gamma screening surveys to determine if these offsite locations require remedial action.

UNITED STATES VANADIUM CORPORATION AND UNION CARBIDE CORPORATION
Uravan, Colorado

Contract No. AT(05-1)-36 was entered into with United States Vanadium Corporation (a subsidiary of Union Carbide Corporation) on April 13, 1949, effective July 1, 1949. Successive amendments extended the contract term through March 31, 1962.

On May 1, 1961, the AEC entered into Contract No. AT(05-1)-795 with Union Carbide Corporation, which had succeeded to United States Vanadium Corporation's rights and obligations under Contract No. AT(05-1)-36. Contract No. AT(05-1)-795, which was effective March 1, 1961, replaced Contract No. AT(05-1)-36 as of that date, and also replaced Contract No. AT(05-1)-675, under which the AEC had been purchasing uranium concentrates from Union Carbide's Rifle, Colorado, operations. Purchases from both facilities were combined under Contract No. AT(05-1)-795.

Contract No. AT(05-1)-795 was rewritten as Modification No. 1, which was executed on October 28, 1965, effective January 1, 1963. The modification extended the contract term through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Under the modification the AEC would continue to purchase uranium concentrate produced by the Uravan and Rifle facilities. It would also purchase concentrates, produced by Union Carbide's milling facility located at Maybell, Colorado, which had been purchased under Contract No. AT(05-1)-797 prior to the effective date of Modification No. 1 to Contract No. AT(05-1)-795.

Modification No. 1 to Contract No. AT(05-1)-795 was negotiated pursuant to the AEC's "stretchout" announcement on November 17, 1962.

Under Contract No. AT(05-1)-36, the AEC paid negotiated prices for the U_3O_8 in concentrate. Under Contract No. AT(05-1)-795, the AEC paid a negotiated price for U_3O_8 in concentrate purchased through March 31, 1962. In the period April 1, 1962 through December 31, 1968 the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, for uranium concentrate attributable to contractor-controlled ore sources, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs in the 1963-1968 period, as determined by an audit of mining and milling costs. In the same period (1969-1970) the AEC paid a fixed price of $6.70 per pound U_3O_8 in concentrate attributable to ores purchased by the contractor from independent ore producers, as required by its November 17, 1962 announcement.

During the period 1949-1959, the AEC purchased vanadium concentrate (in the form of fused vanadium oxide) which was produced by the Uravan mill and which was in excess of the amounts which could be absorbed by the commercial market. For the V_2O_5 contained in vanadium concentrate the AEC paid a negotiated price of $0.98475 per pound.

Millfeed for the Uravan facility came from numerous underground mines in the Uravan Mineral Belt area of southwestern Colorado and southeastern Utah. About 74 percent of the ore processed in the plant during the period of the AEC contracts was mined from properties controlled by the contractor, and about 26 percent was purchased by the contractor from independent ore producers in the area. A small quantity of ore, less than one-tenth of one percent, was acquired by the contractor from the AEC.

Except for periods of about six months in 1981 and 1982, Union Carbide has continued operation of the Uravan mill for the production of uranium and vanadium concentrates for sale in the commercial market.

The Uravan millsite, including the 184 acre townsite, consisting of approximately 335 acres, is located at Uravan, Colorado, 50 air and 90 road miles south-southwest of Grand Junction, Colorado, adjacent to the San Miguel River. The mill itself is divided into two areas. One plant, consisting of ore receiving, crushing, grinding, leaching and solids washing by countercurrent decantation, is situated on the canyon rim of Club Mesa several hundred feet above the river. An older plant, which now only separates and concentrates the uranium and vanadium contained in the leach liquor from the upper plant, is located on the canyon floor adjacent to the river. The total facility consists of the mill, mine/mill offices, warehouses, the Uravan townsite, and liquid and solid waste areas.

The site is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, under Public Law 96-540. A detailed description of the millsite and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume 11, June 30, 1982.

Prior to the period of the AEC contracts the Uravan site had been used for the recovery of radium (1915-1923) and vanadium (1936-1945). Additionally, from 1942 to 1945, under contracts with the Manhattan Engineer District, Union Carbide processed vanadium tailings at the Uravan site for the production of a "green sludge", containing about 20% U_3O_8. This product was shipped to Grand Junction, Colorado, where Union Carbide operated a Government-owned (MED) plant which processed the sludge to further concentrate the uranium. These operations ceased with the drop in demand for vanadium and uranium as World War II ended in 1945.

At the inception of Contract No. AT(05-1)-36, the Uravan mill was reactiviated, using a salt-roast, water leach for vanadium recovery and neutralization and chemical upgrading for the recovery of uranium, attaining a capacity of about 500 tons per day (tpd) in 1950. In 1955 the new "B" plant was constructed on the canyon rim of Club Mesa above Uravan, expanding the mill capacity to 1,000 tpd. The "B" plant uses "hot-acid leaching" rather than the salt-roast process used in the old mill. Both uranium and vanadium are taken into solution during the highly oxidizing two-stage acid leaching. The solids (tailings) are washed in an eight-stage countercurrent decantation circuit. The uranium-vanadium solution from the "B" plant flows by gravity downhill to the old mill where it is clarified and then passed through ion exchange columns for uranium recovery. The resin is eluted with brine and the uranium is precipitated with ammonia to produce concentrate. The vanadium in the ion exchange effluent is recovered by solvent extraction. Various vanadium products from Uravan have included fused vanadium oxide, ferric vanadate, or higher vanadium grade liquors for shipment elsewhere for vanadium recovery.

By 1976 the Uravan mill had a capacity of 1,300 tpd, due to expansion of the acid leaching circuit in the "B" plant.

During the period of the AEC contracts (1949-1970) the Uravan mill processed ore at an average rate of about 800 tpd and treated a total of 5,728,778 tons of ore averaging 0.23% U_3O_8 and 1.20% V_2O_5. Uranium recovery averaged 91 percent. Of the U_3O_8 produced through 1970, 97 percent was sold to the AEC and 3 percent was sold commercially. During the period, vanadium concentrates containing 9,738,791 pounds of V_2O_5 were purchased by the AEC under the contracts.

Tables 1 and 2 present data on AEC purchases of U_3O_8 and V_2O_5 from Union Carbide's Uravan operation and mill production during the term of the AEC contracts.

Table 1 - AEC Purchases of U_3O_8 from UCC-Uravan, CO.

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-036	1950[a]-1961	10,719,208	11.18
AT(05-1)-795	1961-1971[b]	13,138,502	7.87
Total	1950 - 1971	23,857,710	9.34[c]

a) First U_3O_8 delivered 3/50.
b) Last U_3O_8 delivered 12/70.
c) Average Fiscal Year costs ranged from $6.70 to $12.55.

Table 2 - Mill Production Data - UCC-Uravan, CO.

	AEC Contracts
Period of Operation	12/49-12/70
Uranium Ore	
Fed to Process (Tons)	5,728,778[1/]
U_3O_8 (%)	0.23
U_3O_8 (Lbs.)	26,804,004
V_2O_5 (%)	1.20
V_2O_5 (Lbs.)	137,127,942
Other Millfeed	
U_3O_8 (Lbs.)	234,318
V_2O_5 (Lbs.)	9,145,793
Total Millfeed	
U_3O_8 (Lbs.)	27,038,322[2/]
V_2O_5 (Lbs.)	146,273,735[2/]
Production	
U_3O_8 in Conc. (Lbs.)	24,619,976
U_3O_8 Recovered (%)	91
U_3O_8 Shipped to AEC (Lbs.)	23,860,024
U_3O_8 Shipped to Others (Lbs.)	728,919
U_3O_8 Ending Inventory (Lbs.)	31,033
V_2O_5 in Fused Oxide (Lbs.)	[3/]
V_2O_5 Shipped to AEC (Lbs.)	9,738,791[4/]

1/ Includes all ore fed to both the old mill and "B" plant which commenced operation in 1955.

2/ Adjusted totals accounting for plant inventory changes were 26,989,261 lbs. U_3O_8 and 145,959,655 lbs. V_2O_5.

3/ V_2O_5 fused oxide production ceased at Uravan in February 1962, after that all V_2O_5 or other vanadium products were produced at Rifle.

4/ V_2O_5 fused oxide production at Uravan through February 1962 was 38,061,853 lbs. of which 26 percent was purchased by the AEC. Deliveries from Uravan represented 34 precent of the total V_2O_5 purchased by the AEC. However, UCC could have delivered as much as 28,350,000 lbs. V_2O_5 to the AEC under its contract.

During the term of the AEC contracts there were about 5.7 million tons of tailings impounded at the Uravan millsite. During the 1950-1956 period, tailings were deposited in a pond (now called the "sludge" pond) covering about 4.5 acres in area and 20 feet in height, located on the bank of the San Miguel River. During a

period from 1956-1960 tailings were deposited on Club Mesa in separate sand and slime ponds, which were later reprocessed for vanadium. Since 1960, the tailings have gone directly to three tailings piles (two are combined) on Club Mesa, encompassing a total area of about 80 acres. Tailings, as of May 1981, had reached a height of around 155 feet in the combined area and about 110 feet in the other pile. The total tailings impounded in all areas as of the end of the calendar year 1981 was approximately 9.9 million tons.

The tailings areas have not undergone stabilization, but are closely monitored for radiation and particulates. Because the tailings impoundment areas on Club Mesa are about full Union Carbide has started to investigate the possibility of other areas for impounding tailings from future mill operation.

PORTER BROTHERS CORPORATION
Lowman, Idaho

The Porter Brothers Corporation entered into an AEC Contract No. AT(49-6)-985 for the sale of uranium recovered during the chemical processing of a columbite-euxenite concentrate by the Mallinckrodt Chemical Works at its Hemitite, Missouri, plant. The contract term was for the period March 21, 1955, to June 30, 1960. The AEC paid a negotiated price for the U_3O_8 in concentrate throughout the period of the contract. The contract was administered by the AEC's Division of Raw Materials, Washington, D.C.

The Lowman mill was unique in that the ores treated were different from those processed at all other uranium mills. Heavy minerals, recovered as a dredge concentrate from placer deposits, were further upgraded by virtue of their physical characteristics. Neither fine grinding nor chemical processing was employed. Porter Brothers operated the heavy minerals separation mill at Lowman from 1956 to 1960. During that time about 200,000 tons of dredge concentrate were processed for recovery of columbite-euxenite and monazite, plus several byproducts such as magnetite, ilmenite, zircon and garnet. The residues or tailings consisted of approximately 90,000 tons of a variety of sands that are radioactive in varying degress (the equivalent of ores analyzing 0.01 to 0.22% U_3O_8).

After the mill ceased operation it was dismantled and the site has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the Lowman site is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has been assigned a "low" priority for remedial action.

The Lowman millsite and sands area, approximately 37 acres, is located about one-half mile northeast of Lowman, Idaho, in Boise County. Lowman is about 75 miles northeast of Boise. The topography of the site is characterized by steep, pine-covered mountains of the Boise National Forest. Mountain peaks in the immediate vicinity rise to elevations of over 6,000 feet.

The site is presently owned by Velsicol Chemical Corporation, formerly known as the Michigan Chemical Corporation of Chicago, Illinois.

No data are available on the mill production. The millfeed was a jig concentrate of heavy minerals obtained from Bear Valley, 20 miles north of Lowman. The jig concentrate was trucked to the mill for further beneficiation. The Lowman milling process consisted of wet and dry circuits utilizing classifiers, electromagnetic and electrostatic separators, and wet and dry-tabling operations to separate the various products. About 5,000 tons of unprocessed millfeed, assaying 0.22% U_3O_8, remain on the site.

The Lowman uranium-bearing mill concentrates were treated on a toll basis for the Porter Brothers Corporation by Mallinckrodt Chemical Works at Hemitite, Missouri. Mallinckrodt recovered columbium and tantalum pentoxides, uranium oxide, rare earths, titanium, and thorium-iron residues. Porter Brothers sold the U_3O_8 to the AEC and the columbium-tantalum pentoxides to the General Service Administration. Some byproduct magnetite and ilmenite was shipped to the AEC in Las Vegas, Nevada,

for stemming material required during large hole drilling at the Nevada Test Site and some of the garnet sands were used for sand blasting. All of the U_3O_8 recovered by Mallinckrodt was purchased by the AEC and was shipped directly to the AEC's Feed Materials Plant. Table 1 presents data on AEC purchases of U_3O_8 from Porters Brothers Corporation.

Table 1 - AEC Purchases of U_3O_8 from Porter Brothers Corporation-Lowman, ID

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(49-6)-985	1957[a]-1960[b]	365,231	15.01[c]

a) First U_3O_8 delivered 8/56.
b) Last U_3O_8 delivered 3/60.
c) Average Fiscal Year costs ranged from $15.00 to $15.02.

The original mill buildings were removed from the site, but the concrete foundations remain, as well as the scale house, concrete walls of the millfeed storage bins, a wooden water tank, some sheds, and a scrap pile. Gravel and dirt roads interlace the area.

Radioactive sands or residues from the milling operation are deposited in about 10 separate locations on the site. The combined area of all the sands and unprocessed millfeed is approximately 5 acres. The sand residues are dense and coarse-grained, and therefore are fairly resistant to both wind and water erosion. An engineering assessment of the site in 1977, revised as of September 1981, indicates that, in addition to the radioactive sands and untreated jig concentrate totaling about 90,000 tons, there are an estimated 100,000 tons of contaminated soil covering about 36 acres both on and off-site. The site is about 80 percent covered with native grasses and trees but there is no vegetation on the sand piles. No stabilization cover has been placed on the sands or residues. The site is partially fenced and a lockable gate bars car and truck entrance but not cyclists or hikers.

Mobile gamma radiation surveys of the Lowman and Boise areas have identified an estimated eight locations that may require remedial action. These surveys were followed by a comprehensive radiological assessment of the land and facilities on Highway 21 in Boise, formerly occupied by the mill owners and currently occupied by the Idaho Department of Parks and Recreation. The assessment confirmed the presence of residual radioactive materials from the Lowman site and on November 18, 1980, the property was designated by the DOE for remedial action. Additional ground radiological surveys are planned by the DOE to determine if other vicinity properties require remedial action.

KERMAC NUCLEAR FUELS CORP., KERR-MCGEE OIL INDUSTRIES, INC., & KERR-MCGEE CORPORATION
Ambrosia Lake, New Mexico

Contract No. AT(05-1)-729 was entered into on May 3, 1957 with Kermac Nucear Fuels Corp. for a term extending through December 31, 1966. The contract was rewritten as Modification No. 2, executed on August 28, 1964, effective as of January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 2 was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962.

At various times over the period of the contract, through corporate mergers, the contractor was identified as Kermac Nuclear Fuels Corp., Kerr-McGee Oil Industries, Inc., and Kerr-McGee Corporation.

Under the contract the AEC paid negotiated prices for U_3O_8 purchased in the period ending March 31, 1962. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's costs during the 1963-1968 period, as determined by an audit of mining and milling costs. During the 1969-1970 period, none of the uranium concentrate purchased by the AEC under the contract was attributable to ore purchased by the contractor from independent producers.

During the contract period ores for the Ambrosia Lake mill came from underground mines in the Ambrosia Lake area, chiefly those controlled by the contractor. Ninety-three percent of the millfeed during the period was produced by contractor-controlled mines, four percent was purchased from independent ore producers, and one percent was acquired from the AEC. Toll milling for others accounted for the other two percent.

Kerr-McGee's concentrate deliveries to the AEC ended in December of 1969. Operation of the mill has continued since that time for the production of uranium concentrates for sale in the private market. The millsite is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed study of the millsite and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

Kerr-McGee's Ambrosia Lake millsite, consisting of approximately 2,280 acres, is located about 23 road miles north of Grants, New Mexico. The mill began operations in November of 1958 with a nominal capacity of 3,630 tons per day (tpd). It produced uranium for sale to the AEC through December 31, 1969 but under the provisions of the AEC contract Kerr-McGee could have produced and sold uranium concentrate to the AEC through December 31, 1970. During the 12 year period of the AEC contract the mill processed ore at an average rate of about 3,000 tpd and treated a total of 13,230,218 tons of ore averaging 0.21% U_3O_8, plus other millfeed (heap leach material and uranium from mine water) containing 455,383 pounds of U_3O_8. Recovery from the combined millfeed averaged 97 percent. Of the U_3O_8 produced through 1970, 70 percent was delivered to the AEC and 21 percent was sold commercially.

Included in the ore millfeed was lignite ash received from Kerr-McGee's uraniferous lignite burning plant near Bowman, North Dakota. The Bowman plant operated for about three years (1964-1966) and shipped an estimated 607,000 pounds of U_3O_8 in ash to the Ambrosia Lake mill. The ash was slurried and fed to the ore leaching circuit at a rate of 60 to 100 tpd for recovery of both uranium and molybdenum. The Bowman plant site and operation are described in the report section, "Other Uranium Processing Plants."

Although the mill's rated capacity has been increased to 7,000 tpd, there have been no major process changes. Ore is leached with sulfuric acid, and the pregnant solution is then separated from the sand and slime solids in a countercurrent decantation circuit, utilizing cyclones, classifiers, and thickeners. Sodium chlorate and steam are added at several places in the leach circuit to maintain oxidation potential and temperature. The pregnant solution is clarified and sent to the solvent extraction circuits where an organic phase is used to collect uranium and molybdenum. The loaded organic is then fed to a stripping circuit where a brine (sodium chloride) solution separates the uranium from the organic phase. Uranium is precipitated from the highly enriched brine solution through the use of ammonia. Molybdenum is recovered from the organic phase by scrubbing it with an ammonia solution.

A 400 tpd sulfuric acid plant, constructed in conjunction with the mill facilities, supplies the acid requirements for the mill process.

In addition to the milling process, Kerr-McGee also operates two ion exchange facilities, one located at the millsite and another at its Section 36 mine, to remove uranium from mine waters. The units treat about 2,500 and 1,500 gallons per minute, respectively. Subsequent to ion exchange for uranium recovery, the waters are treated with barium chloride to precipitate barium sulfate which picks up radium sulfate as a co-precipitate.

Kerr-McGee also attempted heap leaching of ore at the mill and at several of its mine sites, but the operations were not successful and the leach piles were cleaned up and the material was fed to process at the mill.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Kerr-McGee's Ambrosia Lake operation and mill production data during the term of the AEC contract. No data are available on byproduct molybdenum production.

Table 1 - AEC Purchases of U_3O_8 from Kerr-McGee Corp.-Ambrosia Lake, NM

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-729	1959[a]-1970[b]	43,302,213	7.49[c]

a) First U_3O_8 delivered 12/58.
b) Last U_3O_8 delivered 12/69.
c) Average Fiscal Year costs ranged from $5.67 to $8.00.

Table 2 - Mill Production Data - Kerr-McGee Corp.-Ambrosia Lake, NM

	AEC Contracts
Period of Operation	11/58 - 12/31/70[1/]
Uranium Ore	
Fed to Process (Tons)	13,230,218[2/]
U_3O_8 (%)	0.21
U_3O_8 (Lbs.)	55,862,937
Other Millfeed	
U_3O_8 (Lbs.)	455,383
Total Millfeed	
U_3O_8 (Lbs.)	56,318,320
Production	
U_3O_8 in Conc. (Lbs.)	54,803,959
U_3O_8 Recovered (%)	97
U_3O_8 Shipped to AEC (Lbs.)	43,294,595
U_3O_8 Shipped to Others (Lbs.)	9,294,736
U_3O_8 Ending Inventory (Lbs.)	2,214,628

1/ Although AEC contract term was through CY 1970, KM delivered no U_3O_8 to the AEC after 12/69.

2/ At the end of CY 1969, KM had processed 11,948,899 tons of ore, and produced 50,084,659 lbs. U_3O_8. Ore fed includes lignite ash from Bowman, ND.

At the termination of the AEC contract there were about 12.6 million tons of tailings impounded at the Ambrosia Lake millsite, covering an estimated area of about 290 acres. As of December 31, 1981, the solid tailings areas covered about 330 acres, containing approximately 30 million tons of tailings, ranging to a height of 90 feet. Tailings solution and evaporation ponds occupy another 210 acres.

The quantity of estimated tailings at the end of CY 1970 is somewhat less than the quantity of ore fed to process because Kerr-McGee used about 600,000 tons of sand tailings for mine backfill. Backfilling was used in the underground Ambrosia Lake mines to prevent surface subsidence and intermixing of aquifers, to improve safety, and to permit more complete ore recovery.

The mill is currently operating and stabilization of tailings has not been undertaken. Stability is maintained in compliance with orders of the State Engineer to maintain minimum length of tailings beach in relation to elevation of the tailings pile.

No tailings, other than those used for mine backfill, have been removed from the millsite, which is surrounded by fencing and is controlled access area. No one lives in the immediate vicinity of the mill, the closest community (San Mateo) being about 12 miles southeast of the site.

PHILLIPS PETROLEUM COMPANY AND UNITED NUCLEAR CORPORATION
Ambrosia Lake, New Mexico

Contract No. AT(05-1)-737 was entered into on September 17, 1957, for a term extending through December 31, 1966. In February of 1963 the contract was acquired by United Nuclear Corporation, along with Phillips' ore processing mill and mining properties in the Ambrosia Lake area. In March 1963, United Nuclear ceased feeding ore to the Ambrosia Lake mill, having arranged to process ores through the Homestake-Sapin mill near Grants, New Mexico, for the production of concentrates for sale to the AEC under Contract No. AT(05-1)-737. United Nuclear Corporation was a limited partner in the Homestake-Sapin partnership, which became United Nuclear-Homestake Partners in April of 1968.

Contract No. AT(05-1)-737 was rewritten as Modification No. 4, executed on August 5, 1965, effective January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final deliveries through February 5, 1971. Modification No. 4 was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962. United Nuclear had the option under the contract either to operate its Ambrosia Lake mill or to have ores processed through the Homestake-Sapin (later United Nuclear-Homestake) facility. It chose to have its ores processed at the latter facility from April 1, 1963, through the term of the contract.

The AEC paid negotiated prices for the U_3O_8 under the contract through March 31, 1962. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement.

In the period January 1, 1969, through December 31, 1970, for uranium attributable to contractor-controlled ore sources, the AEC paid a negotiated price for U_3O_8 in concentrates based on the contractor's production costs during the 1963-1968 period, as determined by an audit of mining and milling costs. In the same period (1969-1970) the AEC paid a fixed price of $6.70 per pound of U_3O_8 in concentrate attributable to ores purchased by the contractor from independent ore producers, as required by its November 17, 1962 announcement.

Ores processed under Contract No. AT(05-1)-737 came primarily from underground mines in the Ambrosia Lake area near Grants, New Mexico. Fifty-seven percent of the ore processed at the Ambrosia Lake mill was mined from contractor-controlled sources. Forty-one percent was purchased from independent producers and two percent was acquired from the AEC.

The Ambrosia Lake mill has not operated since it was closed down in 1963, although the main mill building has been used to house a resin ion exchange system to recover uranium from mine waters. The site has been designated and assigned a "medium" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the millsite and tailings is contained in the Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Ambrosia Lake millsite, consisting of about 200 acres, is located in McKinley County, about 20 miles north of Grants, New Mexico. The mill began operations in June of 1958 with a capacity of about 1,750 tons of ore per day (tpd). It produced uranium for sale to the AEC through May of 1963. During that period the mill processed ore at an average rate of about 1,800 tpd and treated 3,050,000 tons of ore averaging 0.23% U_3O_8. Recovery averaged 93 percent. During the period of the mill operation no uranium concentrate was delivered to others than the AEC.

The mill utilized the carbonate leaching process. The circuit was conventional in that the alkaline mill solutions were continuously recirculated in a closed circuit operation; the solutions being regenerated through the use of caustic soda for uranium precipitation, recarbonation with CO_2 gases, and the supplemental addition of soda ash as required. The mill differed from others using the carbonate process in that pressurized Pachuca tanks were used in the leaching operation. Pregnant solutions were separated from the leached solids in three stages of drum filters, with washing methods and techniques of solution recirculation being carefully controlled. To avoid vanadium contamination in the uranium precipitate, a roasting and water leaching system was installed. The method involved roasting with soda ash to produce a calcine from which vanadium could be removed by water leaching, leaving a purified uranium product as the insoluble residue.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Phillips' and United Nuclear's Ambrosia Lake operation and mill production data for the period of the AEC contract during which the mill was operated.

Table 1 - AEC Purchases of U_3O_8 from Phillips Pet. Co. & United Nuc. Corp. Ambrosia Lake, NM

Contract No.	Contractor	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-737	Phillips Pet. Co.	1959[a]-1963	11,981,611	7.89
AT(05-1)-737	United Nuc. Corp.	1963[b]	985,085	8.01
Total		1959 - 1963	12,966,696	7.90[c]

a) First U_3O_8 delivered 8/58.
b) Last U_3O_8 delivered 5/63 from the Ambrosia Lake mill.
c) Average Fiscal Year costs ranged from $7.71 to $8.09.

Table 2 - Mill Production Data - Phillips Pet. Co. & United Nuclear Corp.- Ambrosia Lake, NM

	AEC Contract
Period of Operation	6/1/58-5/31/63[1/]
Uranium Ore	
Fed to Process (Tons)	3,050,000
U_3O_8 (%)	0.23
U_3O_8 (Lbs.)	14,036,662
Production	
U_3O_8 in Conc. (Lbs.)	13,015,896
U_3O_8 Recovered (%)	93
U_3O_8 Shipped to AEC (Lbs.)	12,965,929
U_3O_8 Shipped to Others (Lbs.)	0
U_3O_8 Ending Inventory (Lbs.)	49,967[2/]

1/ Last ore fed in March 1963 but concentrate was produced and shipped in April and May 1963 from the Ambrosia Lake mill.

2/ Ending inventory was transferred to Homestake-Sapin Partners mill and delivered from that mill under Contract 737.

During the period of its operation the mill generated about 3 million tons of tailings. Some 400,000 tons of the mill tailings were used by United Nuclear for mine filling, so as of April of 1981 there were about 2.6 million tons of tailings at the site, covering an area of approximately 105 acres to an average thickness of about 12 feet.

Some of the mill buildings are used for office, laboratory, and storage purposes, and the main mill building is used to house a resin ion exchange system to recover uranium from mine waters. This uranium enters process in the United Nuclear-Homestake Partners mill (now the Homestake mill).

No tailings, other than those tailings used for mine filling, are known to have been removed from the millsite area. Dikes composed of native soil and tailings have been constructed around the edge of the pile. The tailings have not been stabilized with vegetation cover, although some weeds have established themselves in the pile. Windblown tailings have migrated north of the pile and past the eastern fenceline.

There are no permanent residences in the vicinity of the site although a small trailer park is located on State Highway 509 about one mile west of the tailings pile. Radiological surveys in the Ambrosia Lake area have indicated that there are no offsite structures which will require remedial action.

ANACONDA COPPER MINING COMPANY AND THE ANACONDA COMPANY
Bluewater, New Mexico

Contract No. AT(49-1)-550 was entered into on December 27, 1951, with The Anaconda Copper Mining Company. It was replaced by Contract No. AT(05-1)-773, entered into with The Anaconda Company on December 11, 1959, effective May 1, 1959 through December 31, 1966. Contract No. AT(05-1)-773 was rewritten as Modification No. 1, executed on December 27, 1963, effective January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 1 was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962.

Under Contract No. AT(49-1)-550, and through March 31, 1962 under Contract No. AT(05-1)-773, the AEC paid negotiated prices for the U_3O_8 in concentrates. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, the AEC paid a negotiated price for U_3O_8 in concentrates, based on the contractor's production costs during the 1963-1968 period, as determined by an audit of mining and milling costs.

The mill operated essentially on ores derived from contractor-controlled mines. About 94 percent of its total millfeed came from those sources, primarily from the Jackpile and Paguate mines located on the Laguna Indian Reservation some 50 miles east of the mill. About 4 percent of the ore feed was purchased from independent producers and about 2 percent was bought from the AEC.

After the expiration of Contract No. AT(05-1)-773, The Anaconda Company continued to operate the mill until early 1982 for production of uranium for private sales. The plant has since been put into a standby condition.

The site is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed description of the Bluewater site and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

The Anaconda millsite, near the village of Bluewater, New Mexico, is 11 miles northwest of Grants and just north of the main line of the Santa Fe Railroad and Interstate Highway I-40. The millsite covers about 5,100 acres including the Anaconda townsite that provides housing for some employees. The mill has provisions for receiving ore shipments by both rail and truck haulage. The site was initially selected for the treatment of the Todilto Limestone ores discovered nearby in 1950.

These high-lime ores were unamenable to acid leaching and required use of the hot carbonate leach process. To facilitate development of the carbonate leach process, Anaconda constructed and operated a small pilot plant at Bluewater that treated about 350 tons of ore during the period March until October 1953 when it was shut down. It was this pilot plant production (2,230 lbs. U_3O_8 in concentrate) that constituted the initial Anaconda delivery of U_3O_8 to the AEC in September 1953.

To stimulate exploration and ore production in the area, the AEC engaged Anaconda as an ore purchasing agent under separate contracts [AT(49-1)-619 and 901]. During the period FY 1952-1958, Anaconda received, sampled and stockpiled 320,726 tons of ore averaging 0.32% U_3O_8 and 0.18% V_2O_5. Anaconda purchased from the AEC and processed in the mill 182,280 tons of this ore, averaging 0.36% U_3O_8, and sold the resulting uranium concentrate to the AEC. The remainder of the ore was sold by the AEC to other mill operators.

The original 300 ton per day (tpd) carbonate leach mill began operation in October 1953. In 1955, it was expanded to 1,200 tpd and began treating both limestone and sandstone ores. The carbonate mill operated until May 1959, when it was shut down permanently.

With the discovery in 1951 of the massive Jackpile sandstone uranium deposit, a few miles north of Laguna, Anaconda entered into a contract modification that provided for the construction of an acid-leach, resin-in-pulp (RIP) mill capable of processing 2,000 tpd. The acid-leach mill started operating in December 1955 and continued processing ore at a rate of 1,600 to 1,800 tpd during the AEC contract period.

Shortly after termination of its AEC contracts, Anaconda expanded the mill capacity to 4,000 tpd. Then, in 1978, Anaconda further increased the capacity to 6,000 tpd and installed a solvent extraction section to replace the RIP circuit. These latter expansions were undertaken to permit the treatment of lower grade ores.

Subsequent to the AEC contracts period, Anaconda was acquired by the Atlantic Richfield Co. (ARCO) and operated as a division of that company until the mill was shut down in February 1982 and placed in standby at the end of March 1982.

The AEC purchases of U_3O_8 from Anaconda are shown in Table 1 along with the average cost per pound of U_3O_8. Table 2 gives mill production data for the terms of the AEC contracts and an Anaconda estimate of the total tonnage of ore processed at Bluewater from startup in 1953 through December 1981. Some small additional tonnage may have been fed to process before shutdown in February 1982.

Table 1 - AEC Purchases of U_3O_8 from The Anaconda Co.-Bluewater, NM

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(49-1)-550	1954[a]-1959	17,191,109	10.18
AT(05-1)-773	1959-1971[b]	22,458,528	7.88
Total	1954 - 1971	39,649,637	8.88[c]

a) First U_3O_8 delivered 9/53 from pilot plant operation.
b) Last U_3O_8 delivered 12/70.
c) Average Fiscal Year costs ranged from $4.62 to $14.90.

Table 2 - Mill Production Data - The Anaconda Co.-Bluewater, NM

	AEC Contracts
Period of Operation	10/53-12/31/70
Uranium Ore	
Fed to Process (Tons)	10,032,560[1/]
U_3O_8 (%)	0.24
U_3O_8 (Lbs.)	48,590,085
Production	
U_3O_8 in Conc. (Lbs.)	48,014,024
U_3O_8 Recovered (%)	93
U_3O_8 Shipped to AEC (Lbs.)	39,576,176
U_3O_8 Shipped to Others (Lbs.)	3,682,771

1/ Anaconda estimated for the Commingled Uranium Tailings Study, that a total of 23,586,000 tons of ore was fed to process from start-up through CY 1981.

At the termination of the AEC contract, there were slightly over 10 million tons of tailings impounded in three separate piles at the Bluewater millsite, occupying a total area of 341 acres. At the end of calendar year 1981, the tailings piles contained a total of about 23.6 million tons of solids, still occupying the same area.

No tailings have been released for removal from the millsite area and none have been reprocessed. However, in the period 1960-1977, under an amendment to its license, Anaconda used an injection well for disposal of decant liquid from its largest (270 acre) tailings disposal area. The waste liquid was discharged into the Mesa Blanca member of the Yeso Formation (Permian). Since that time the waste liquids have gone into lined evaporation ponds. Only the two smaller piles (47 acres and 24 acres) have undergone some stabilization, having been covered with an average of 30 inches of soil.

HOMESTAKE-NEW MEXICO PARTNERS
Grants, New Mexico

Contract No. AT(05-1)-724 was entered into on December 20, 1956 with Homestake-New Mexico Partners, composed of Homestake Mining Company as general partner and the following limited partners: Rio de Oro Uranium Mines, Inc.; United Western Minerals Company; J.H. Whitney & Company; White, Weld & Company; San Jacinto Petroleum Corporation; and Clyde Osborn. The contract provided for a term through March 31, 1962. However, on November 9, 1961, Homestake-Sapin Partners acquired the assets of Homestake-New Mexico Partners, including Contract No. AT(05-1)-724 and the New Mexico Partner's uranium processing plant, which was adjacent to that of the Sapin partnership. Concurrently, Contract No. AT(05-1)-724 was replaced by Contract No. AT(05-1)-905 between the AEC and Homestake-Sapin Partners.

Contract No. AT(05-1)-905 in effect replaced both the Homestake-New Mexico Partners contract (724) and an existing contract (789) with Homestake-Sapin Partners combining the quantities to be purchased by the AEC and the two processing facilities (thenceforth called the Homestake-Sapin Complex) under the single new contract with Homestake-Sapin Partners.

The term of Contract No. AT(05-1)-905 originally extended through December 31, 1966. However, the contract was rewritten as Modification No. 1, executed on June 23, 1965, effective as of January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 1 was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962.

Meanwhile, as of April 2, 1962, United Nuclear Corporation was merged into Sabre Pinon Corporation (the limited partner in the Homestake-Sapin Partnership), and the surviving corporation was re-named United Nuclear Corporation. That corporation then became the limited partner. Later, in April of 1968, the partnership became United Nuclear-Homestake Partners.

Under the contracts the AEC paid negotiated prices for U_3O_8 purchased through March 31, 1962. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement. In the period January 1, 1969 through December 31, 1970, for uranium attributable to contractor-controlled ore sources, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs during the 1963-1968 period as determined by an audit of mining and milling costs. In the same period (1969-1970) the AEC paid a fixed price of $6.70 per pound of U_3O_8 in concentrate attributable to ores purchased by the contractor from independent ore producers, as required by the November 17, 1962 announcement.

Ore for the milling operations came from underground mines in the Ambrosia Lake and Smith Lake areas near Grants, New Mexico. In addition to milling ore for the production of concentrates under Contract No. AT(05-1)-905 and its predecessors, the Homestake-Sapin Complex also milled ore for the production of uranium concentrate for sale to the AEC by United Nuclear Corporation under Contract No. AT(05-1)-737, which was acquired by United Nuclear from Phillips Petroleum Company in February

of 1963. After acquiring the Phillips contract and milling operation, United Nuclear Corporation ceased feeding ore to the Phillips Ambrosia Lake mill in March of 1963 and arranged with Homestake-Sapin to process United Nuclear's ore for production of concentrate for sale to the AEC under Contract No. AT(05-1)-737 until its expiration at the end of 1970.

During the period of operation under the Contract 724, Homestake-New Mexico Partners produced 78 percent of the ore fed to process in the mill and purchased 22 percent of its millfeed from independent ore producers and the AEC. Ore acquired from the AEC amounted to only 16,443 tons or less than 2 percent of the total millfeed.

That portion of the Complex which had been the Homestake-New Mexico Partners mill ceased operations in April of 1962, although portions of the plant continued to be used in conjunction with the larger Homestake-Sapin (later United Nuclear-Homestake) mill, which has continued to operate since the expiration of Contracts AT(05-1)-905 and 737. The millsite is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed description of the millsite and tailings is contained in their report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

The Homestake-New Mexico Partners (NHMP) millsite is located in the south half of Section 26, T. 12 N., R. 10 W., approximately 7 miles north of Grants, New Mexico, on State Highway 53, the main route to the Ambrosia Lake uranium mining area. The HNPM millsite occupies the southern portion of the 1,500 acres of the Homestake property that encompasses both the HNMP and Homestake mills and tailings impoundment areas. The Homestake property is about 9,000 feet in an east-west direction and 8,500 feet in a north-south direction. The site is on relatively level ground that slopes gently to the south and west. There are two tailings piles on the site, the inactive HNMP pile, and the active Homestake pile. The small inactive pile, approximately 40 acres in area, is southwest of the HNMP mill.

The HNMP mill, the first one built to process Ambrosia Lake ores, commenced operation in February 1958. As noted earlier, it ceased operation in April 1962, although portions of the mill are still used in conjunction with operation of the Homestake mill. The HNMP mill had a capacity of 750 tons of ore per day (tpd) but operated during its life at an average rate of about 850 tpd. Uranium recovery averaged 90 percent and all uranium concentrate produced was shipped to the AEC.

The alkaline or carbonate leach process used at the HNMP mill was of generally conventional design. Open Pachuca tanks were used to leach the ground ore at a temperature of 180°F for 36 hours. The pregnant solution was separated from the leached residue (tailings) by use of a thickener and two stages of drum filters. Uranium was precipitated from solution by caustic soda addition.

Vanadium contamination of the uranium concentrates was a significant problem from the beginning of operations at the mill. The problem was solved by re-treating the initial concentrate with a reducing roast, water leach process. The roast rendered the vanadium water soluble so that it could be dissolved from the calcine, leaving a uranium concentrate that met AEC concentrate specifications. The concentrate was dried, packaged and shipped to Grand Junction.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from the Homestake-New Mexico Partners and mill production for the period of time it operated as a separate mill.

Table 1 - AEC Purchases of U_3O_8 from Homestake-N.M. Partners-Grants, NM

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-724	1958[a]-1962	4,260,000	8.54
AT(05-1)-905	1962[b]	736,753[c]	8.00
Total	1958 - 1962	4,996,753	8.45[d]

a) First lot delivered 4/58.
b) Last lot delivered 5/62.
c) Homestake estimate of U_3O_8 delivered at HNMP mill under contract 905.
d) Average Fiscal Year costs ranged from $8.00 to $8.69.

Table 2 - Mill Production Data - Homestake New Mexico Partners-Grants, NM

	AEC Contracts[1]		
	HNMP (724)	HSP (905)	Total
Period of Operation	2/58 - 8/31/61[2]	9/1/61 - 4/62	2/58 - 4/62
Uranium Ore			
Fed to Process (Tons)	1,048,686	193,088	1,241,774[3]
U_3O_8 (%)	0.23	0.21[4]	0.22
U_3O_8 (Lbs.)	4,756,880	810,970	5,567,850
Production			
U_3O_8 in Conc. (Lbs.)	4,261,944	734,809	4,996,753[5]
U_3O_8 Recovered (%)	90	91	90[5]
U_3O_8 Shipped to AEC (Lbs.)	4,246,522	750,231	4,996,753[5]
U_3O_8 Shipped to Others (Lbs.)	0	0	0
U_3O_8 Ending Inventory (Lbs.)	15,422[6]		

1/ Mill operated by HNMP until 9/1/61, then it became part of the Homestake-Sapin Partners (HSP) Complex until millfeed ceased in April 1962.

2/ AEC Production Data Book data for HNMP operation through 8/31/61.

3/ Total ore fed to process calculated by DOE for Commingled Uranium Tailings Study. Homestake's total was 1,223,193 tons.

4/ Average millfeed grade for HSP Complex 9/1/61 - 4/62. U_3O_8 (lbs.) in ore fed was calculated from this average feed grade.

5/ In lieu of actual production of this mill, when operated as part of the HSP Complex, it was assumed that all U_3O_8 produced was delivered to the AEC; i.e., equal to actual purchases Table 1.

6/ Ending HNMP inventory transferred to HSP, and shipped to AEC under Contract 905.

Questions arose during consideration of Public Law 95-604 as to whether the HNMP site should be included in the uranium mill tailings remedial action program. Although the tailings were inactive and not commingled with tailings from commercial operations, the site had become part of a continuing active milling operation. As required by Title III of Public Law 95-604, the Nuclear Regulatory Commission conducted a study and concluded that it or the State of New Mexico has the authority to require the owner (Homestake) to control all mill tailings at the site. Hence the HNMP tailings site is not one of the inactive sites designated under PL-604 or subsequently by the Secretary of Energy.

The HNMP tailings pile contains an estimated 1.24 million tons of tailings in a 40 acre pentagon-shaped area. The tailings are contained with an embankment of earth and soils excavated on the site. The pile has been covered to a depth of a few feet over 20 percent of its area with contaminated soils excavated from beneath a tailings spill from the larger active pile. In addition, approximately 50 percent of the surface has been covered with scrap materials discarded from mill operations. The covering was done to help prevent wind erosion and dusting. Also, some grass cover has been established on the pile. No tailings are known to have been removed from the HNMP inactive tailings pile.

HOMESTAKE-SAPIN PARTNERS
Grants, New Mexico

Contract No. AT(05-1)-721 was entered into on April 23, 1957 with Homestake-Sapin Partners, a limited partnership consisting of Homestake Mining Company as general partner and Sabre-Pinon Corporation as limited partner. On July 27, 1960, that contract was replaced by Contract No. 789, which provides for a term extending through December 31, 1966. On November 9, 1961, Contract No. AT(05-1)-789 was replaced by Contract No. 905. Concurrently, Homestake-Sapin acquired the assets of Homestake-New Mexico Partners, including Homestake-New Mexico's AEC Contract No. AT(05-1)-724 and its uranium processing plant, which was adjacent to the Homestake-Sapin mill. Thereafter, the milling facilities were known as the Homestake-Sapin Complex, and concentrates from both milling operations were purchased by the AEC under Contract No. AT(05-1)-905, which replaced the former Homestake-New Mexico contract (724) as well as the earlier Homestake-Sapin contract (789).

As of April 2, 1962, United Nuclear Corporation was merged into Sabre-Pinon Corporation and the surviving Corporation was re-named United Nuclear Corporation. That corporation became the limited partner in the Homestake-Sapin partnership. Later, in April of 1968, the partnership became United Nuclear-Homestake Partners.

Contract No. AT(05-1)-905 was rewritten as Modification No. 1 executed on June 23, 1965, effective as of January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 1 was negotiated pursuant to the AEC's "stretch-out" announcement of November 17, 1962.

Under the contracts the AEC paid negotiated prices for U_3O_8 through March 31, 1962. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, for uranium attributable to contractor-controlled ore sources, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs during the 1963-1968 period, as determined by an audit of mining and milling costs. In the same period (1969-1970) the AEC paid a fixed price of $6.70 per pound of U_3O_8 in concentrate attributable to ores purchased by the contractor from independent ore producers, as required by its November 17, 1962 announcement.

Ore for the milling operations came from underground mines in the Ambrosia Lake and Smith Lake areas near Grants, New Mexico. In addition to milling ore for the production of concentrates under Contract No. AT(05-1)-905 and its predecessors, the Homestake-Sapin Complex also milled ore for the production of uranium concentrate for sale to the AEC by United Nuclear Corporation under Contract No. AT(05-1)-737, which was acquired by United Nuclear from Phillips Petroleum Company in February of 1963. After acquiring the Phillips contract and milling operation, United Nuclear Corporation ceased feeding ore to the Phillips Ambrosia Lake mill in March of 1963 and arranged with Homestake-Sapin to process United Nuclear's ore for production of concentrate for sale to the AEC under Contract No. AT(05-1)-737 until its expiration at the end of 1970.

Ore fed to the Homestake-Sapin Partners mill (later the Homestake Sapin Complex, then the United Nuclear-Homestake Complex), including ore processed for United Nuclear under Contract 737, was 84 percent contractor-owned (Homestake and Sabre-Pinon, later United Nuclear). Sixteen percent was purchased from independents, and less than half of one percent was acquired from the AEC. Ore fed to the Homestake-New Mexico Partners mill was 78 percent contractor mine production, 21 percent purchased ore, and one percent acquired from the AEC.

That portion of the Complex which had been the Homestake-New Mexico Partners mill ceased operations in April of 1962, although portions of the plant continued to be used in conjunction with the larger Homestake-Sapin (later United Nuclear-Homestake) mill, which has continued to operate since the expiration of Contracts AT(05-1)-905 and 737. The millsite is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed description of the millsite and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

The Homestake-Sapin (later United Nuclear-Homestake) mill is located on a 1,500 acre site about 6 miles north of Milan, New Mexico. (Milan is 80 miles west of Albuquerque on Interstate Highway 40 and 2 miles west of Grants.)

The mill began operations in May 1958, with a capacity of 1,650 tons per day (tpd). The mill processed both limestone and sandstone ores, but presently the sandstone ore constitutes nearly all of the millfeed. Ore grades as mined range from 0.04 to 0.30 percent U_3O_8, so ore lots are selectively crushed and blended.

The mill utilizes an alkaline leach-caustic precipitation process for uranium recovery. Since the adjacent Homestake-New Mexico Partners mill was closed down in 1962, the Homestake-Sapin mill has utilized a portion of that mill, including Pachuca tanks and related mill circuitry. With addition of the grinding facilities and circuitry of the Homestake-New Mexico mill, the capacity of the Homestake-Sapin mill was increased to 3,500 tpd.

The mill utilizes two parallel circuits in grinding, thickening, and leaching. In the grinding circuit the ore is ground to about 50 percent minus 200-mesh in a sodium carbonate and sodium bicarbonate mill solution. The grinding circuit slurry is then thickened to about 40 percent solids and sent to the leaching circuit.

Extraction takes place in a two-stage circuit, where the pH is 11. The first stage is a pressure leach at 60 psi, and 200°F followed by an atmospheric leach. The leached slurries are pumped to filters where soluble uranium is removed by three stages of countercurrent filtration. The filtrate is the pregnant solution that is clarified and sent to the precipitation circuit after being heated to 180°F. Caustic soda is used to raise the pH above 12, which precipitates the uranium as sodium diuranate. The primary precipitation of concentrate is followed by processing to remove vanadium and other impurities. The uranium is then re-precipitated as ammonium diuranate containing about 85 percent U_3O_8 which is dried and packaged.

The decant solution recycled from the tailings pond is returned to the mill where it is processed in an ion exchange circuit for uranium removal.

Besides processing raw ore, the Homestake-Sapin mill treated material from Homestake Sapin's dump-leach operation at its Section 26 mine, which started in 1966 and was operated intermittently until 1976.

Both during and after the AEC contract period, the Homestake-Sapin mill also recovered uranium from mine water pumped from its Section 23 and Section 25 mines and from United Nuclear's Section 34 mine.

During the period of the AEC contracts the mill processed ore at an average rate of about 2,700 tpd and treated a total of 11,608,206 tons of ore averaging 0.20% U_3O_8, plus other millfeed containing 627,694 pounds of U_3O_8. Recovery from the combined millfeed averaged 93 percent. Of the U_3O_8 produced through 1970, 86 percent was delivered to the AEC and 14 percent was sold in the commercial market.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Homestake-Sapin's Grants operation and mill production data during the term of the AEC contracts.

Table 1 - AEC Purchases of U_3O_8 from Homestake-Sapin Partners-Grants, NM

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-721	1959[a]-1960	2,799,374	8.59
AT(05-1)-789	1960 - 1962	3,216,925	8.01
AT(05-1)-905	1962-1970[c]	19,218,994[b]	7.78
AT(05-1)-737	1963-1970[c]	12,020,378	7.87
Total	1959 - 1970	37,255,671	7.88[d]

a) First U_3O_8 delivered 9/58.
b) Homestake calculated 19,218,747 lbs. delivered from this mill under Contract 905; however, to equal the actual total AEC purchases of U_3O_8 under 905, it was necessary to add 247 lbs. to Homestake's figure.
c) Last U_3O_8 delivered 6/70 under both contracts 737 and 905.
d) Average Fiscal Year costs ranged from $5.91 to $8.61

Table 2 - Mill Production Data - Homestake-Sapin Partners-Grants, NM

	AEC Contracts			
	HSP (721 & 789)	UN-HP (905)	UNC (737)	Total
Period of Operation	7/1/58 - 8/31/61	9/1/61 - 12/31/70	4/1/63 - 12/31/70	7/1/58 - 12/31/70
Uranium Ore				
Fed to Process (Tons)	1,725,772	6,416,210[1/]	3,466,224[2/]	11,608,206
U_3O_8 (%)	0.20	0.19	0.22	0.20
U_3O_8 (Lbs.)	6,880,001	23,754,193	15,012,651	45,646,845
Other Millfeed				
U_3O_8 (Lbs.)	--	408,157	224,537	627,694
Total Millfeed				
U_3O_8 (Lbs.)	6,880,001	24,157,350	15,237,188	46,274,539
Production				
U_3O_8 in Conc. (Lbs.)	6,132,400	22,817,924	14,109,610	43,059,934
U_3O_8 Recovered (%)	89	94	93[3/]	93
U_3O_8 Shipped to AEC (Lbs.)	6,115,967	19,098,015	12,011,672[3/]	37,225,654
U_3O_8 Shipped to Others (Lbs.)	0	1,524,619	2,916,611[3/]	4,441,230
U_3O_8 Ending Inventory (Lbs.)	16,433	109,171	1,283,879	1,393,050

1/ Feed to HNMP mill excluded.

2/ Feed to Phillips mill excluded.

3/ UNC shipments exceeded production because UN-HP transferred 2,102,351 lbs. U_3O_8 in concentrate to UNC during 1969 and 1970.

At the termination of the AEC contract there were two tailings piles at the site -- one active and the other inactive. The inactive site, attributable to the operation of the Homestake-New Mexico Partners mill during the 1958-1962 period, contained about 1.2 million tons of tailings, covering an area of approximately 40 acres. Tonnage and acreage remained unchanged as of the end of calendar year 1981. All tailings in the inactive pile are ascribable to production of uranium for sale to the AEC. The active tailings area, attributable to the operation of the Homestake-Sapin mill, contained about 11.6 million tons of tailings at the end of the AEC contracts period. As of December 31, 1981, the active pile covered an area of 170 acres and contained about 19.7 to 19.9 million tons of tailings, as estimated by Homestake and DOE respectively.

Interim stabilization, consisting of covering with scrap materials discarded from mill operations and with several feet of contaminated soil, plus seeding to establish vegetation, has been undertaken on about 20 acres of the inactive pile. The sides and upper embankment of the active pile are periodically sprayed with a latex base compound to help prevent wind and rain erosion, and the precipitation on the tailings surface of some of the carbonate compounds used in the milling process also aids in stabilizing the coarser tailings on the upper embankment of the pile.

No tailings have been removed from the millsite property. A break in the active tailings pond in 1977 resulted in some tailings solution and solids flowing onto company-owned property adjacent to the active pile. The solid tailings were retrieved, the land decontaminated, and the dikes strengthened to prevent future accidental releases.

KERR-MCGEE OIL INDUSTRIES, INC., VANADIUM CORPORATION OF AMERICA, & FOOTE MINERAL CO.
Shiprock, New Mexico

Contract No. AT(05-1)-230 was entered into with Kerr-McGee Oil Industries, Inc. on August 17, 1953. It was replaced by Contract No. AT(05-1)-785, entered into on November 24, 1959, for a term beginning November 1, 1959 and ending June 30, 1965, with an option in the AEC to extend the term through December 31, 1966. The option was exercised on August 16, 1961.

On March 1, 1963, the Shiprock mill was sold by Kerr-McGee to Vanadium Corporation of America (VCA) and Contract No. AT(05-1)-785 was assigned to VCA. At that time Vanadium Corporation of America had an existing AEC contract (AT(05-1)-900), providing for the purchase of concentrates produced at VCA's Durango, Colorado, mill. Concidentally with its purchase of the Shiprock plant, VCA closed down the Durango milling operation and began processing ores at Shiprock to produce uranium concentrates under Contract No. AT(05-1)-900, as well as Contract No. AT(05-1)-785.

Contract No. AT(05-1)-900 was rewritten as Modification No. 1, which was executed on November 26, 1965, effective as of January 1, 1963. The modification merged Contract No. AT(05-1)-785 into Contract No. AT(05-1)-900 effective March 1, 1963, and extended the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 1 was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962.

Under the contracts the AEC paid negotiated prices for U_3O_8 in concentrate purchased through March 31, 1962. In the period April 1, 1962 through August of 1968, when concentrate deliveries ceased, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement.

Vanadium Corporation of America was merged into Foote Mineral Company on August 31, 1967, and Foote continued the Shiprock milling operation until May of 1968 when operations ceased.

Ores for the Shiprock mill came from mines in the northern portion of the Navajo Indian Reservation, and other widely dispersed areas of the Colorado Plateau in Colorado, New Mexico, Arizona, and Utah. After Vanadium Corporation of America assumed operation of the mill from Kerr-McGee on March 1, 1963, a portion of the Shiprock millfeed also consisted of dried slime concentrates and chemical precipitates produced by VCA's concentrating plants located near the Monument No. 2 mine in Monument Valley, Arizona. The VCA-Foote operations in Monument Valley are discussed in the report section, "Other Uranium Processing Plants".

Fifty-six percent of the ore fed to process at the Shiprock plant came from contractor-controlled mines. Thirty-two percent was purchased from independent producers, and twelve percent was acquired from the AEC.

The AEC established a uranium ore buying station at Shiprock on January 7, 1952. The station was operated for the AEC by its contractor, American Smelting and Refining Company (AS&R), which at that time also operated ore buying stations at Monticello and Marysvale, Utah. The Shiprock ore buying station provided a market for uranium-vanadium bearing ores from northeastern Arizona and northwestern New Mexico, most of which came from the Navajo Indian Reservation. AS&R

operated the ore receiving and sampling facility until November 1, 1954 when the mill was completed and Kerr-McGee assumed operation of the facility. During the period when ore was purchased by the AEC a total of 129,638 tons of ore averaging 0.28% U_3O_8 and 1.08% V_2O_5 was accumulated. All this ore was subsequently sold to Kerr-McGee along with ore from some other AEC ore buying stations. Kerr-McGee bought a total of 186,035 tons of ore averaging 0.31% U_3O_8 and 1.02% V_2O_5 from the AEC. The U_3O_8 recovered from this ore in the Shiprock mill was purchased by the AEC under the uranium concentrate procurement contracts.

The Shiprock site, consisting of 230 acres, is located on the south side of the San Juan River on the Navajo Indian Reservation just south of the community of Shiprock, New Mexico. The country is generally arid and desertlike, with low rolling hills and sparse vegetation, except along the river. The site was leased from the Navajo Nation and when the Foote Mineral Company's lease expired in 1973, full control of the site reverted to the Navajo Nation. The site has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. It has been given a "high" priority for remedial action because of nearby residents. A detailed description of the Shiprock millsite and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The mill was constructed and was operated from 1954 to 1963 by Kerr-McGee Oil Industries, Inc. It began operation in November 1954 at a nominal capacity of 300 tons of uranium-vanadium ore per day. Later additions of equipment and process modifications increased the capacity to 500 tons per day (tpd). During the seven years and four months the mill was operated by Kerr-McGee a total of 944,420 tons of ore was fed to process. The ore feed averaged 0.26% U_3O_8 and 0.88% V_2O_5. Kerr-McGee produced 4,559,473 pounds U_3O_8 in concentrate and shipped 4,524,236 pounds U_3O_8 to the AEC. Kerr-McGee also produced 5,914,212 pounds V_2O_5 in fused oxide, none of which was purchased by the AEC.

During the five years and two months that VCA and Foote operated the Shiprock mill, 582,767 tons of uranium-vanadium ore were fed to process. The millfeed averaged 0.23% U_3O_8 and 1.38% V_2O_5, and VCA-Foote recovered 2,863,423 pounds U_3O_8 and 14,544,316 pounds V_2O_5. VCA-Foote shipped 2,897,264 pounds U_3O_8 and no V_2O_5 to the AEC from Shiprock.

With regard to vanadium recovery at Shiprock it should be noted that the AEC paid for the vanadium contained in ores initially purchased by AS&R and by Kerr-McGee during the period of operation under Contract 230. The AEC was to be reimbursed by Kerr-McGee as vanadium was produced. However, Kerr-McGee experienced problems in producing vanadium and for several years vanadium rich solutions were placed in evaporation ponds for possible future recovery of the vanadium. The AEC retained title to the vanadium in these ponds, as well as that contained in the tailings. Under a separate royalty agreement (Contract No. AT(05-1)-791), Kerr-McGee paid a royalty to the AEC on vanadium recovered from those sources. As noted earlier, Kerr-McGee did recover some vanadium, actually 36 percent of that fed to process, and paid the required AEC royalty on production. Contract No. AT(05-1)-791 was assigned by Kerr-McGee to VCA when VCA assumed the mill operation on March 1, 1963, and some minor amount of royalty was paid the AEC by VCA under that arrangement. When it appeared that the recovery of additional vanadium would be economically unattractive, the AEC relinquished its right to the contained vanadium and it became the property of VCA.

The original uranium-vanadium mill utilized an "acid cure" process to improve the recovery of vanadium from the relatively low lime, high vanadium ore. There were materials handling problems with the initial mill design so the acid cure was abandoned in favor of conventional agitation leach in 1955. Concurrently, Kerr-McGee added a solvent extraction (SX) circuit to supplement the original fixed-bed ion exchange circuit. The SX circuit operated so well that eventually the operation of the ion exchange unit was discontinued.

The mill used conventional ore crushing, and grinding, followed by a two stage hot sulfuric acid leach with oxidant to solubilize both the uranium and vanadium. After liquid solids separation in classifiers and thickeners, the pregnant solution was treated by separate SX circuits to recover first the uranium, then the vanadium. Uranium recovery averaged about 94 percent for the life of the mill and vanadium recovery only 58 percent.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from the Shiprock mill and mill production data for the term of the AEC contracts, the life of the mill. As noted in Table 2, some of the feed for the Shiprock mill came from the VCA-Foote operations in Monument Valley, Arizona at the Monument No. 2 mine on the Navajo Indian Reservation.

Table 1 - AEC Purchases of U_3O_8 from Kerr-McGee and VCA-Foote-Shiprock, NM

Contract No.	Contractor	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-230	Kerr-McGee Oil Inc.	1955[a]-1960	3,090,658	10.85
AT(05-1)-785	Kerr-McGee Oil Inc.	1960 - 1963	1,455,321	8.00
AT(05-1)-900	(Vanadium Corp. of Am. (Foote Mineral Co.	1963-1969[b]	2,900,409	8.00
Total		1955 - 1969	7,446,388	9.18[c]

a) First U_3O_8 delivered 1/55.
b) Last U_3O_8 delivered 8/68.
c) Average Fiscal Year costs ranged from $7.99 to $13.13.

Table 2 - Mill Production Data - Kerr-McGee and VCA-Foote-Shiprock, NM

	AEC Contracts
Period of Operation	11/54 - 5/68[1]
Uranium Ore	
Fed to Process (Tons)	1,527,187[2]
U_3O_8 (%)	0.26
U_3O_8 (Lbs.)	7,895,893[3]
V_2O_5 (%)	1.16
V_2O_5 (Lbs.)	35,376,092[3]
Production	
U_3O_8 in Conc. (Lbs.)	7,422,896
U_3O_8 Recovered (%)	94
U_3O_8 Shipped to AEC (Lbs.)	7,421,500
U_3O_8 Shipped to Others (Lbs.)	1,390
V_2O_5 in Fused Oxide (Lbs.)	20,458,528
V_2O_5 Recovered (%)	58[4]
V_2O_5 Shipped to AEC	None

1/ KM operated the mill from startup in 11/54 through 2/63. VCA assumed operation 3/1/63 until 8/31/67 when VCA was merged into Foote Mineral Co. Foote continued operations until May 1968.

2/ Ore feed only, excludes tonnage of slime concentrates, chemical precipitates and other feeds from the Monument No. 2 upgrader, concentrator, and heap leach and possibly Durango and Naturita mill clean-up.

3/ Includes 188,409 lbs. U_3O_8 and 2,726,610 lbs. V_2O_5 contained in slime concentrates and other feed for which no weight (tonnage) was added to ore fed to process.

4/ V_2O_5 recovery was low because for part of the time when KM operated the mill no V_2O_5 was recovered. During that time vanadium rich liquors were impounded in solution ponds separate from the main solid tailings impoundment. VCA later recovered some of that vanadium.

In 1968 when milling operations at Shiprock were terminated there were about 1.5 million tons of tailings impounded in two adjacent areas covering approximately 72 acres. The upper (north) pile covers 26 acres and varies from 14 to 40 feet in height. Pit-run soil and gravel have been used to cover this pile to a depth of 0.5 to 2 feet. Some natural vegetation has been established on the pile. The south pile covers 46 acres and is about 15 feet high. Material removed from the mill and ore storage areas during decontamination efforts in the late 1970s was placed in the south pile. The pile is not stabilized but is covered with the material from the decontamination activities.

The elevated millsite eliminates the possibility of flooding or water erosion of the tailings by the San Juan River.

The former mill office, shop and some other smaller buildings have been used by the Navajo Engineering and Construction Authority (NECA) since 1973. It was NECA, under an EPA plan, that began decommissioning the site in January 1975. Primary effort was directed toward returning windblown tailings to the south pile and covering it.

Although some gamma radiation anomalies were reported to have been found at structures in the Shiprock area, the exact extent of tailings use is not yet known. It has been estimated by the DOE that 10 to 15 vicinity properties may require remedial action.

LAKEVIEW MINING COMPANY
Lakeview, Oregon

Contract No. AT(05-1)-743 was entered into on November 18, 1957 for a term extending through November 30, 1963. The mill ceased operations in November of 1960. Because the contractor ceased operations prior to April 1, 1962, the AEC paid a negotiated price for all U_3O_8 in concentrate purchased under the contract. The assets of Lakeview Mining Company were acquired by Kermac Nuclear Fuel Corporation in 1961.

About 85 percent of the millfeed for the plant consisted of ores from the contractor's White King and Lucky Lass mines located in southern Lake County, Oregon. The remaining 15 percent was purchased from independent ore producers in the area.

The mill has not operated since it closed down in 1960. Ownership of the site has changed several times over the years, and the site has been designed for remedial action and assigned a "medium" priority under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the Lakeview millsite and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Lakeview millsite is approximately 2 miles northwest of Lakeview, Oregon, and is adjacent to U.S. Highway 395. The site encompasses 258 acres and is located in a valley and the surrounding area is well vegetated ranchland with occasional ranch homes and barns. Several lumber mills are located nearby. The mill building and other structures remain on the site but salvageable machinery has been removed. The site is now used for a lumber mill.

The Lakeview mill operated for only two years and was shut down for lack of ore. It had a rated capacity of 210 tons of ore per day (tpd) but the actual feed rate varied widely, from only 50 tpd to as much as 400 tpd depending upon the availability of ore. The grade of ore also decreased significantly during the period of operation, averaging about 0.20% U_3O_8 at the beginning but only 0.09% U_3O_8 during the final months of operation. During the mill's operating life a total of 131,355 tons of ore averaging 0.15% U_3O_8 was fed to process. Uranium recovery averaged 87 percent and the total production, 342,259 pounds U_3O_8, was sold to the AEC.

The milling process used was similar to that of the Gunnison mill since it was constructed by the same principals who participated in the Gunnison Mining Company operation at Gunnison, Colorado. The Lakeview process included sulfuric acid leaching and solvent extraction, except that at Lakeview an amine solvent was used.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from the Lakeview Mining Company and the Lakeview mill production for its total life.

Table 1 - AEC Purchases of U_3O_8 from Lakeview Mining Co.-Lakeview, OR

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lbs. U_3O_8 ($)
AT(05-1)-743	1959[a]-1961[b]	342,259	9.62[c]

a) First U_3O_8 delivered 1/59.
b) Last U_3O_8 delivered 11/60.
c) Average Fiscal Year costs ranged from $9.51 to $9.82.

Table 2 - Mill Production Data - Lakeview Mining Co.-Lakeview, OR

	AEC Contract
Period of Operation	12/58 - 11/60
Uranium Ore	
Fed to Process (Tons)	131,355
U_3O_8 (%)	0.15
U_3O_8 (Lbs.)	393,827
Production	
U_3O_8 in Conc. (Lbs.)	342,611
U_3O_8 Recovered (%)	87
U_3O_8 Shipped to AEC (Lbs.)	342,611
U_3O_8 Shipped to Others (Lbs.)	0

The mill tailings occupy about 30 acres; the evaporation ponds, 64 acres; and the millsite, 12 acres. The tailings pile is almost square and has been stabilized with an earth cover of 18 to 24 inches. This cover is supporting a vigorous growth of vegetation. The average depth of tailings including the cover is 3.7 feet. An earth dike was formed around the impoundment area before tailings emplacement. The tailings are fenced with a hog-wire fence, and are posted with radiation warning signs.

The six evaporation ponds are still in their original shapes and are almost completely barren of vegetation, resulting in periodic dust problems. The mill building and other structures have been decontaminated.

Since Kerr-McGee acquired the property its ownership has changed several times. The property was acquired by the Atlantic Richfield Company (ARCO) in 1968, and most of the tailings reclamation and stabilization, as well as the decontamination, were accomplished by ARCO. The current owner is Precision Pine, Inc., which purchased the site in March 1978 and operates a full-scale lumber mill on the property. Precision Pine has taken the position that only the 40 acres of its property that contain tailings should be identified as subject to remedial action.

No evidence of windblown tailings has been found offsite at Lakeview. Gamma radiation surveys in the area have identified some properties with higher than background radiation levels that will require further investigation by the DOE to determine if remedial action is required.

MINES DEVELOPMENT, INC.
Edgemont, South Dakota

Contract No. AT(05-1)-291 was entered into on April 28, 1955, for a term extending through March 31, 1962. It was replaced by Contract No. AT(05-1)-907, entered into on March 19, 1962, effective September 1, 1961, for a period extending through December 31, 1966, with provision for final concentrate deliveries through February 2, 1967. Mines Development, Inc. did not participate in the AEC's "stretchout" program, and Contract No. AT(05-1)-907 expired on December 31, 1966.

On November 10, 1966, the AEC announced a change in its procurement program, under which milling companies not participating in the stretchout could process ores from certain small independent mining properties and sell the resulting uranium concentrate to the AEC in the period January 1,1967 through December 31, 1968. In furtherance of that program the AEC and Mines Development, Inc. entered into Contract No. AT(05-1)-929 on March 14, 1967, effective January 1, 1967, for the purchase by the AEC of uranium concentrates produced by the contractor from such ores. The initial term of the contract was for six months, and modifications of the contract, effective on July 1,1967 and July 1, 1968, extended the term through December 31, 1968.

Under Contract No. AT(05-1)-291, and under Contract No. AT(05-1)-907 in the period prior to April 1, 1962, the AEC paid negotiated prices for the U_3O_8 in concentrate. Thereafter, under Contract No. AT(05-1)-907 and Contract No. AT(05-1)-929, the price was the fixed $8.00 per pound U_3O_8 established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by its November 17, 1962 announcement.

Millfeed for the Edgemont plant came primarily from mines in the Black Hills area of southwestern South Dakota and the northeastern Wyoming. Some ore was shipped from mines near Douglas, Wyoming, and some of the early shipments came from Washington state. Lignite ash from field burning in open heaps near Belfield, South Dakota, also contributed to the millfeed. During the period of the AEC contracts the plant operated as a "custom" mill. Ninety-four percent of the ore processed was purchased from independent ore producers and the other six percent was acquired from the AEC.

After expiration of the AEC contracts, the milling operation continued for the production of uranium and vanadium for sale in the commercial market. Operations ceased in August of 1974, when the Tennessee Valley Authority acquired the mill and certain mineral rights from Susquehanna-Western, Inc., successor to Mines Development, Inc.

The millsite is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed description of the Edgemont millsite and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

The Edgemont mill is located on the east side of Edgemont, Fall River County, in southwest South Dakota, on a rectangular site consisting of about 213 acres. The mill was constructed in late 1955 and early 1956 on property adjacent to an AEC ore buying station. Mines Development purchased the buying station on July 12,

1956, together with the ore stockpile which the AEC had accumulated during its operation of the buying station. The mill began operation in July of 1956 with a nominal capacity of 250 tons per day (tpd), but within a year the capacity was expanded to 400-500 tpd.

The initial flow sheet at Edgemont consisted of ore crushing and grinding, agitation leach with sulfuric acid, countercurrent washing of sands in classifiers, and treatment of the minus 300-mesh slime pulp in the resin-in-pulp process. The uranium-loaded resin beads were eluted with a nitrate solution from which the uranium was precipitated. Mines Development installed the Eluex process in 1958, enabling it to elute with sulfuric acid and to recover the uranium from the solution by means of solvent extraction. Eluex also effected a savings in chemical consumption and permitted recycle of raffinate, and resulted in a higher grade product.

Although the mill treated carnotite-type ores containing about as much vanadium as uranium, vanadium recovery was not instituted until 1960. Later additions to the vanadium circuit enabled Mines Development to handle a variety of vanadium-bearing material, including an iron slag imported from Europe.

Uraniferous lignite ash, derived from field burning of lignite, constituted up to ten percent of the millfeed during the 1963-1967 period. While treating lignite ash, Mines Development also recovered molybdenum as a byproduct.

Because the AEC had paid the miners (and Mines Development) for the vanadium in the ores which constituted the early feed for the mill, Mines Development was required by the AEC to neutralize with lime the resin-in-pulp slime tailings, which contained about 80 percent of the vanadium originally present in the ores, and to impound the precipitated vanadium tailings slimes separately from the tailings sand fraction. In 1960, when Mines Development commenced vanadium recovery, the slimes no longer were neutralized, but were taken directly to vanadium leaching. Beginning in 1962, the earlier neutralized slimes were also repulped and leached for vanadium recovery. A system of ponds was used in place of conventional thickeners for separating the pregnant vanadium liquors from the solids.

During the period of the AEC contracts the mill processed ore at an average rate of about 500 tons per day and treated a total of 1,643,148 tons of ore averaging 0.20% U_3O_8. Recovery averaged 95 percent. Of the U_3O_8 produced during the AEC contract period, nearly 99 percent was delivered to the AEC and the remainder was sold commercially. All of the vanadium produced during the period was sold in the commercial market, as was all uranium concentrate produced after December 31, 1968.

Tables 1 and 2 present data on AEC purchases from the Mines Development, Inc. Edgemont operation and mill production data during the term of the AEC contracts.

Table 1 - AEC Purchases of U_3O_8 from Mines Dev., Inc.-Edgemont, SD

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-291	1957[a]-1962	2,685,232	10.01
AT(05-1)-907	1962 - 1968	3,322,462	8.03
AT(05-1)-929	1967-1969[b]	64,807	8.00
Total	1957 - 1969	6,072,501	8.91[c]

a) First U_3O_8 delivered 8/56.
b) Last U_3O_8 delivered 1/69.
c) Average Fiscal Year costs ranged from $7.99 to $11.45

Table 2- Mill Production Data - Mines Dev., Inc.-Edgemont, SD

	AEC Contract
Period of Operation	7/3/56-12/31/68[1/]
Uranium Ore	
Fed to Process (Tons)	1,643,148
U_3O_8 (%)	0.20
U_3O_8 (Lbs.)	6,460,024
Production	
U_3O_8 in Conc. (Lbs.)	6,142,704
U_3O_8 Recovered (%)	95
U_3O_8 Shipped to AEC (Lbs.)	6,066,881
U_3O_8 Shipped to Others (Lbs.)	74,984
U_3O_8 Ending Inventory (Lbs.)	839
V_2O_5 in Fused Oxide (Lbs.)	3,426,695[2/]

1/ Mill continued to operate through 1972 for recovery of uranium, but data are lacking on post-AEC production.

2/ Vanadium was recovered from ore and other materials from 1960 until the mill shut down in 1974. The AEC purchased no V_2O_5 from MDI.

The Tennessee Valley Authority, which purchased the Edgemont site and facilities in 1974, prepared a decommissioning plan environmental report in 1979, and the Nuclear Regulatory Commission staff then issued a "Draft Environmental Statement Relating to the Decommissioning of the Edgemont Uranium Mill," September 1981.

At the termination of the AEC contract period, there were about 1.6 million tons of tailings impounded at the Edgemont site in eight distinct disposal areas. Three additional tailings ponds were built after the expiration of the AEC contracts period and, as of the end of December 1981, there were approximately 2 million tons of tailings, including residues from vanadium production, in the 11 disposal sites, covering a total area of 123 acres.

About 83 acres of the tailings area has been covered and seeded, with good to excellent vegetation. In the uncovered ponds, trapped water keeps the bottom surfaces moist and blowing of tailings currently does not appear to be a problem.

Radiation surveys of offsite vicinity properties have revealed a number of anomalies, many of which appear to have some uranium tailings involvement, primarily in areas outside the structure themselves. Remedial action on the more highly involved structures is planned to commence in FY 1983.

MINING RESEARCH CORPORATION
Edgemont, South Dakota

Contract No. AT(05-1)-232 was entered into on August 31, 1953, for a term extending through June 30, 1955, with an option in the contractor to extend the term through June 30, 1956. The option was exercised and the contract expired at the end of June 1956.

Mining Research Corporation did not construct or operate a full-scale milling facility. Instead, the contractor conducted pilot plant operations to investigate process technologies for the acid leaching of uranium ores in place (in-situ) and the percolation leaching of low grade mined ores. The acid leach liquors were neutralized to produce rather low grade uranium concentrates which were purchased by the AEC on a negotiated price basis.

Mining Research used ores located on properties it controlled in Fall River County, South Dakota, some 10 miles north of Edgemont. No ore was purchased from independent producers or the AEC.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Mining Research Corporation on the pilot plant operation at the mine site.

Table 1 - AEC Purchases of U_3O_8 from Mining Research Corp.- Edgemont, SD

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-232	1954[a]-1955[b]	2,823	13.97[c]

a) First U_3O_8 delivered in last half of CY 1953.
b) Last U_3O_8 delivered 7/54.
c) Average Fiscal Year costs ranged from $12.71 to $14.24.

Table 2 - Pilot Plant Production Data - Mining Research Corp.- Edgemont, SD[1/]

	AEC Contracts
Period of Operation	Summer 1954
Uranium Ore	
Fed to Process (Tons)	3,788
U_3O_8 (%)	0.06
U_3O_8 (Lbs.)	4,375
Production	
U_3O_8 in Conc. (Lbs.)	2,782
U_3O_8 Recovered (%)	64
U_3O_8 Shipped to AEC (Lbs.)	2,782

1/ Not a mill but a pilot plant operation to develop process technology for in-situ and percolation leaching of uranium ores.

Most of the U_3O_8 purchased from Mining Research Corporation is believed to have been produced by vat leaching of the low grade ore. No data are available on the experimental leaching of an abandoned pillar in Mining Research's Virginia C mine. However, that marked the initial development of the in-situ leach process for which U.S. Patent 2,818,240 was issued to C.W. Livingston, December 31, 1957.

The in-situ leaching tests would not have produced any significant quantity of residues. The percolation leach residues, estimated at slightly less than 4,000 tons, remained at the mine site and probably were discarded with other mine waste in the Black Hills mining area.

SUSQUEHANNA-WESTERN, INC.
Falls City, Texas

Contract No. AT(05-1)-762 was entered into on July 25, 1960, for a term extending through December 31, 1966, with provision for final concentrate deliveries through February 2, 1967. Susquehanna-Western, Inc. did not participate in the AEC's "stretchout" program, and Contract No. AT(05-1)-762 expired on December 31, 1966.

On November 10, 1966, the AEC announced a change in its procurement program, under which milling companies not participating in the stretchout could process ores from certain small independent mining properties and sell the resulting uranium concentrate to the AEC in the period January 1, 1967 through December 31, 1968. In furtherance of that program the AEC and Susquehanna-Western, Inc. entered into Contract No. AT(05-1)-930 on April 14, 1967, effective January 1, 1967, for the purchase by the AEC of uranium concentrates produced by the contractor from such ores. The initial term of the contract was for six months and modifications of the contract, effective July 1, 1967 and July 1, 1968, extended the term through December 31, 1968.

Under Contract No. AT(05-1)-762, in the period prior to April 1, 1962, the AEC paid negotiated prices for the U_3O_8 in concentrate. Thereafter, under Contract No. AT(05-1)-762 and Contract No. AT(05-1)-930, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by its November 17, 1962 announcement.

Millfeed for the Falls City plant came from the southeastern Texas area, chiefly from the contractor's open pit mining operations about two miles from the mill. During the period of the AEC contracts, slightly more than 35 percent of the millfeed was acquired by the contractor from the AEC and a little over 64 percent was mined from contractor-controlled properties. Less than half of one percent was purchased from independent ore producers.

During the period from January 1960 , to May 1961, the AEC purchased ore from San Antonio Mining Company, Inc. and stockpiled the ore on a tract of land about a mile south of the Susquehanna-Western mill. The ore receiving station had no sampling facilities, so provisional payments were made for the ore until it could be reweighed and sampled at the sampling plant constructed by Susquehanna-Western in conjunction with the mill. All of the ore was sold by the AEC to Susquehanna-Western in the 1961-1964 period, to be milled for the production of concentrate for sale to the AEC. Based on final weights and assays, the AEC purchased from San Antonio and sold to Susquehanna-Western a total of 110,917 tons of ore assaying 0.19% U_3O_8 and containing 426,417 pounds of U_3O_8.

The Falls City millsite, consisting of approximately 1,600 acres, is located about 8 miles southwest of Falls City, Texas, and about 35 miles southeast of San Antonio. After expiration of the AEC contracts, the milling operation continued for the production of uranium concentrate for sale in the commercial market. Operation of the mill ceased in August of 1973, and the site has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed

description of the Falls City millsite and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Falls City mill began operations in April 1961, with a nominal capacity of 220 tons of ore per day (tpd). It produced uranium for sale to the AEC through August of 1968. During the period of the AEC contracts (ending December 31, 1968) the mill processed ore at an average rate of about 450 tpd and treated a total of 1,210,300 tons of ore averaging 0.18% U_3O_8. Recovery averaged 95 percent. Of the U_3O_8 produced through 1968, 39 percent was delivered to the AEC and 61 percent was sold commercially. Thereafter, until the mill was shut down in 1973, all production was for commercial sales.

Although the Falls City mill had an original design capacity of 220 tpd, new facilities had been installed to permit expansion to 1,000 tpd by the end of the AEC contracts period at the end of 1968.

The mill process consisted of a sulfuric acid leach; separation of pregnant solutions by countercurrent decantation in a five-stage combined thickener and cyclone circuit; extraction of uranium from the pregnant solutions in a solvent extraction circuit; stripping with a ten percent sodium carbonate solution fed countercurrently to the loaded organic; precipitation of feed solutions low in molybdenum content by initially acidifying the solution to a pH of 3.0 to decompose the carbonate compounds and to drive off the CO_2, then adding caustic soda to a pH of 7.0 to precipitate sodium diuranate, or, for feed solutions containing excess amounts of molybdenum, direct percipitation by adding NaOH until there was an excess of three grams per liter; dewatering, washing, and drying of the yellow cake slurry; and packaging of the uranium concentrate for shipment. The caustic (NaOH) precipitation kept the molybdenum in solution so it would not precipitate with the uranium to produce off-specification concentrates.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Susquehanna-Western's Falls City operation and mill production data during the term of the AEC contracts.

Table 1 - AEC Purchases of U_3O_8 from Susquehanna-Western, Inc. - Falls City, TX

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-762	1961[a]-1967	1,508,002	8.35
AT(05-1)-930	1967-1969[b]	77,194	8.00
Total	1961 - 1969	1,585,196	8.34[c]

a) First U_3O_8 delivered 6/61.
b) Last U_3O_8 delivered 8/68.
c) Average Fiscal Year costs ranged from $8.00 to $10.76.

Table 2 - Mill Production Data - Susquehanna-Wester, Inc.-Falls City, TX

	AEC Contracts
Period of Operation	4/11/61 - 12/31/68[1/]
Uranium Ore	
Fed to Process (Tons)	1,210,300[2/]
U_3O_8 (%)	0.18
U_3O_8 (Lbs.)	4,339,957
Production	
U_3O_8 in Conc. (Lbs.)	4,103,061
U_3O_8 Recovered (%)	95
U_3O_8 Shipped to AEC (Lbs.)	1,585,445
U_3O_8 Shipped to Others (Lbs.)	2,517,616

1/ Effective 5/1/66 a portion of the production was for commercial sales of uranium.

2/ To shutdown in August 1973 a total of about 2.5 million tons of ore averaging 0.16% U_3O_8 had been processed.

At the termination of the AEC contracts there were about 1.2 million tons of tailings impounded at the Falls City site. There are currently some 2.5 million tons of tailings in seven tailings areas encompassing a total of 146 acres. Stabilization has been undertaken at the site, consisting of covering the piles with at least 2 feet of earth, and seeding.

As of the publication of DOE/EP-0011 (April 1981), surveys had disclosed a few offsite locations where contaminated materials had been used around structures, and further ground radiological surveys are being conducted to further define the extent of transportation of residual radioactive material from the site into the surrounding area.

Sometime after the mill shut down about 200 acres of the site, including the mill area and tailings piles 1, 2 and 7, and a portion of pile 5, were acquired by the Solution Engineering Company of Alice, Texas. Solution Engineering commenced production of uranium from in-situ leaching of the tailings in 1978 under license by the State of Texas. Some mill process equipment is used but the details of this operation are not available. Because of this activity, it has been determined that the portion of the site owned by Solution Engineering does not qualify for remedial action under Title I of Public Law 95-604.

The remainder of the site not now owned by Solution Engineering is on lands leased from Lyssy Dairy Farms and Silvestor Niestroy. Presumably that portion of the site qualifies for remedial action and has been assigned a "medium" priority. Tailings on those leased lands are estimated to cover about 50 acres or about 3 percent of the total fenced area considered to be the leased land boundaries.

VANADIUM CORPORATION OF AMERICA
White Canyon (Hite), Utah

Contract No. AT(05-1)-38 was entered into with Vanadium Corporation of America (VCA) on May 17, 1949, effective October 8, 1948, for a term extending through June 30, 1953. Amendments to the contract extended its term through December 31, 1953.

The AEC paid a negotiated price for the U_3O_8 in concentrate purchased under the contract.

Millfeed for the White Canyon mill consisted of copper-uranium ores from the White Canyon district of southeastern Utah, notably from the Happy Jack mine. Practically all of the ore fed to process during the term of the contract was purchased by the contractor from independent ore producers in the area. The remainder (less than one hundreth of one percent) was furnished by the contractor.

The White Canyon facility was located at Hite, in the southeastern Utah area where White Canyon intersects the Colorado River. It was essentially a pilot plant operation, processing an average of about 20 tons of ore per day (tpd) from August of 1949 until it was shut down in December of 1953. During that period the plant treated 26,358 tons of ore averaging 0.43% U_3O_8. Recovery averaged 57 percent. All of the uranium concentrate produced in the plant was sold to the AEC.

The plant used an acid leach process, and the leach liquors were neutralized with excessive sodium carbonate. The resulting alumina sludge was removed and the liquor containing the uranium was then acidified to destroy the carbonate. With the addition of a small amount of caustic the uranium was precipitated as sodium diuranate.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from VCA's White Canyon operation and mill production data for the period of the AEC contract.

Table 1 - AEC Purchases of U_3O_8 from Vanadium Corporation of America-White Canyon, UT

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-38	1950[a]-1954[b]	128,145	13.93[c]

a) First U_3O_8 delivered late CY 1949.
b) Last U_3O_8 delivered 12/53.
c) Average Fiscal Year costs ranged from $11.45 to $14.48.

Table 2 - Mill Production Data - Vanadium Corporation of America-White Canyon, UT

	AEC Contract
Period of Operation	7/49-12/53
Uranium Ore	
Fed to Process (Tons)	26,358
U_3O_8 (%)	0.43
U_3O_8 (Lbs.)	224,573
Production	
U_3O_8 in Conc. (Lbs.)	128,280
U_3O_8 Recovered (%)	57
U_3O_8 Shipped to AEC (Lbs.)	128,280

From the quantity of ore fed to process in the plant, it is assumed that some 26 thousand tons of tailings were impounded at the site when the plant closed down. Some "high grade" tailings were removed from the site by VCA in the mid-1960s, presumably for reprocessing at its Shiprock, New Mexico mill.

After expiration of the AEC contract the mill was dismantled. In November of 1963 the AEC requested the Department of Health, Education and Welfare to determine the radiation effect of the tailings pile if it were to remain at the site, which would ultimately be covered by the waters of Lake Powell. Based on that analysis, it was concluded that the tailings could remain at the site. Subsequent radiochemical analyses of water and sediment samples indicated no significant variation in levels of radioactivity between samples collected over the tailing pile (by then covered with sediment) and samples taken upstream and downstream from the site, and the location has not been included in any remedial action program.

TEXAS-ZINC MINERALS CORPORATION AND ATLAS CORPORATION
Mexican Hat, Utah

Contract No. AT(05-1)-696 was entered into with Texas-Zinc Minerals Corporation on July 17, 1956, for a term extending through March 31, 1962. It was modified on August 6, 1958, to extend the contract term through December 31, 1966, with provision for final concentrate deliveries through February 2, 1967. The modification also provided for the purchase by Texas-Zinc of AEC-owned ore stockpiles at White Canyon, Utah.

On July 31, 1963, Atlas Corporation acquired Texas-Zinc Minerals Corporation. At that time Contract No. AT(05-1)-696 was terminated, and the quantities of U_3O_8 in concentrate to be purchased by the AEC under the contract were consolidated into and purchased under an existing contract (Contract No. AT(05-1)-266) under which Atlas Corporation was operating its Moab, Utah, mill. Thereafter, Atlas operated the Mexican Hat mill through its subsidiary, A-Z Minerals, until it closed down the plant at the end of February 1965.

Under Contract No. AT(05-1)-696, the AEC paid negotiated prices for U_3O_8 in concentrate purchased through March 31, 1962. Thereafter, until the contract was terminated on July 31, 1963, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement.

Ore for the Mexican Hat mill came primarily from the Whtie Canyon and Red Canyon mining areas in southeastern Utah. During the operation of the mill by Texas-Zinc and Atlas, 25 percent of the millfeed was furnished by contractor-controlled mines, 65 percent was purchased from independent ore producers, and 10 percent was acquired from the AEC.

The AEC had an ore buying station in the White Canyon area, near the Happy Jack mine, where ore was purchased from October 1954 through July 1957. A total of 179,635 tons averaging 0.25% U_3O_8 was bought and stockpiled. Also, for a short period of time the AEC purchased a small quantity of ore delivered to the Texas-Zinc mill during the period June 1959 through February 1960. Only 4,297 tons of ore averaging 0.21% U_3O_8 were purchased under this arrangement. The ore purchased at White Canyon and Mexican Hat was sold to Texas-Zinc for processing, along with a little ore from other AEC ore buying stations. In total, Texas-Zinc acquired 212,349 tons of ore averaging 0.26% U_3O_8 from the AEC.

The Mexican Hat millsite, consisting of about 555 acres, is located in the extreme southeast corner of Utah, about 15 miles north of the Arizona state line, on the Navajo Indian Reservation. The mill has not been operated since it was closed down by Atlas Corporation in 1965. The mill was built on land leased from the Navajo Nation and, when the Atlas lease expired in 1970, control of the buildings and the site reverted to the Navajo Nation.

The site has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the millsite and tailings is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Mexican Hat mill began operations in November of 1957 with an initial capacity of 775 tons of ore per day (tpd), which was expanded in 1958 to 1,000 tpd. It produced uranium for sale to the AEC through February of 1965. During that period the mill processed ore at an average rate of about 850 tpd and treated a total of 2,199,480 tons of ore averaging 0.28% U_3O_8. Recovery averaged 93 percent. All of the U_3O_8 produced by the mill was delivered to the AEC.

The mill process consisted of crushing, sampling, and grinding; flotation of a copper sulfide concentrate; leaching with sulfuric acid and manganese dioxide in separate copper and uranium circuits and filtration of leached copper concentrates; five-stage countercurrent decantation of the main leach pulp, which contained the bulk of uranium in solution; clarification of the pregnant liquor in pressure-type filters; uranium recovery by solvent extraction and precipitation of uranium oxide by neutralizing the loaded acidified nitrate with magnesium hydroxide; thickening, washing, and filtering; and drying and packaging the uranium concentrate. The copper concentrate was shipped to a smelter.

The Texas-Zinc solvent extraction circuit was unique in that centrifugal (Podbielniak) contactors were used, the only mill ever to use "Pods" instead of mixer-settlers. Another item of interest was the constructing in 1956 of a 33 mile road by the company to shorten the ore truck haulage distance from the White Canyon and Red Canyon mining areas to the mill. Haulage was shortened by 44 miles. The road was given to the State of Utah in 1957 and is still part of the State road system.

In addition to the uranium milling operation, which shut down in 1965, a 70-ton sulfuric acid plant was operated at the Mexican Hat site until 1970.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Texas-Zinc and Atlas' Mexican Hat operation and mill production data during the period of the operation.

Table 1 - AEC Purchases of U_3O_8 from Texas-Zinc Minerals Corp. and Atlas Corp., Mexican Hat, UT

Contract No.	Contractor	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-696	Texas-Zinc	1958[a]-1964	9,642,021	9.02
AT(05-1)-266	Atlas Corp.	1964-1965[b]	1,742,406	8.00
Total		1958 - 1965	11,384,427	8.86[c]

a) First U_3O_8 delivered 11/57.
b) Last U_3O_8 deliverd 3/65.
c) Average Fiscal Year costs ranged from $8.00 to $9.37.

Table 2 - Mill Production Data - Mexican Hat, UT

	AEC Contracts
Period of Operation	10/1/57 - 2/28/65
Uranium Ore	
Fed to Process (Tons)	2,199 480
U_3O_8 (%)	0.28
U_3O_8 (Lbs.)	12,176,707
Production 1/	
U_3O_8 in Conc. (Lbs.)	11,384,427
U_3O_8 Recovered (%)	93
U_3O_8 Shipped to AEC (Lbs.)	11,384,427
U_3O_8 Shipped to Others (Lbs.)	0

1/ No data are available on byproduct copper production.

When the mill ceased operation there were approximately 2.2 million tons of tailings impounded at the site in two adjacent tailings piles covering 68 acres. The tailings were deposited in ponds formed by use of natural slopes, with earth dikes constructed at the lower sides of the slopes. The tailings range in depth up to 40 feet.

The tailings have not been stabilized, and erosion has carried some of the tailings down the natural washes toward the San Juan River, which is about three-fourths of a mile north of the northerly boundary of the tailings area.

The milling equipment has been removed, but most of the mill buildings remain intact. The mill housing area, located about six-tenths of a mile southwest of the millsite, has become a small settlement called Halchita, with a popuation of about 300.

Gamma radiation surveys, employing mobile scanning units, have detected several anomalies among the offsite structures scanned in the Mexican Hat area.

A Department of Energy aerial survey, conducted in 1980, and a ground radiological survey, scheduled to be conducted in 1981, will further define the extent of any transporation of residual radioactive material from the site, which has been assigned a "medium" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

URANIUM REDUCTION COMPANY AND ATLAS CORPORATION
Moab, Utah

Contract No. AT(05-1)-266 was entered into with Uranium Reduction Company on June 1, 1955, for production of uranium concentrate at Moab, Utah. On August 3, 1956, the contract was extended through December 31, 1966. Uranium Reduction Company was merged into Atlas Corporation on August 1, 1962, and an assignment of the contract from Uranium Reduction Company to Atlas Corporation was approved by the AEC on August 17, 1962.

On July 31, 1963, Atlas acquired a second uranium processing plant which had been constructed in 1956 and 1957 at Mexican Hat, Utah, by Texas-Zinc Minerals Corporation for the production of uranium concentrate for sale to the AEC under Contract No. AT(05-1)-696. Coincident with Atlas' acquisition of the Mexican Hat mill, Contract No. AT(05-1)-696 was terminated and the quantities of U_3O_8 in concentrate to be purchased by the AEC under that contract were consolidated into and purchased under Contract No. AT(05-1)-266. While continuing to operate the Moab mill, Atlas also operated the Mexican Hat plant through a subsidiary, A-Z Minerals Corporation, until the end of February, 1965, when the Mexican Hat plant was closed down.1/

Contract No. AT(05-1)-266 was rewritten as Modification No. 5, executed on December 10, 1964, effective January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 5 was negotiated pursuant to the AEC's "stretch-out" announcement of November 17, 1962.

Under Contract No. AT(05-1)-266 the AEC paid negotiated prices for the U_3O_8 in concentrates purchased through March 31, 1962. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through December 31, 1970, for uranium attributable to contractor-controlled ore sources, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs during the 1963-1968 period, as determined by an audit of mining and milling costs. In the same period (1969-1970), the AEC paid a fixed price of $6.70 per pound of U_3O_8 in concentrates attributable to ores purchased by the contractor from independent ore producers, as required by its November 17, 1962 announcement.

Ores from the Moab mill came primarily from mines in southeastern Utah and southwestern Colorado. Ore purchased from independent miners accounted for about 60 percent of the millfeed. About 25 percent of the ore was produced by URC-Atlas-controlled mines, and about 15 percent was sold to Atlas by the AEC. There is no mine near the mill. All ore is hauled by truck from the many mines (20 to 70) that the mill serves. The average haul distance is about 50 miles.

1/ Information concerning Contract No. AT(05-1)-696 and the operation and site of the Mexican Hat mill is contained in the report on Texas-Zinc Minerals Corporation at Mexican Hat, Utah.

An AEC ore buying station was located adjacent to Atlas' Moab millsite and during the period FY 1954-1960 a total of 687,685 tons of ore averaging 0.33% U_3O_8 and 0.49% V_2O_5 was purchased and stockpiled at that site by the AEC. Most of that ore was purchased by Atlas from the AEC.

Additionally, during the period FY 1958-1964, Atlas served as an ore purchasing agent for the AEC under a separate contract (AT(05-1)-753), using money advanced by the AEC to acquire ores from independent producers needing a market in the area. A total of 154,828 tons of ore averaging 0.54% U_3O_8 was purchased by Atlas for the AEC under that arrangement. Atlas subsequently bought that ore from the AEC, as well as some ore from the AEC ore buying station at Monticello, Utah. In all, Atlas acquired from the AEC 879,404 tons of ore averaging 0.39% U_3O_8. Atlas received 57,459 tons of ore in 1966 from Vitro after the Vitro mill ceased uranium production. Atlas purchased 3,862,366 tons of ore from other producers during the period of its AEC contract.

The Atlas millsite, consisting of approximately 400 acres, is located about 3 miles northwest of the city of Moab, Utah, adjacent to the Colorado River. Atlas continues to operate the Moab mill for production of uranium for private sales.

The site is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed description of the Moab tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011), Volume II, June 30, 1982.

The Moab mill began operations in October 1956 with a capacity of 1,500 tons of ore per day (tpd). It produced uranium for sale to the AEC through December 1970. During that period of time the mill processed ore at an average rate of about 1,400 tpd and treated a total of 6,354,733 tons of ore averaging 0.34% U_3O_8. Recovery averaged 96 percent. Of the U_3O_8 produced through 1970, 93 percent was delivered to the AEC and 7 percent was sold commercially. All production after 1970 has been for private sales.

The mill has undergone several major process changes. Initially, the milling process used consisted of a sulfuric acid leach, sand-slime operation, and treatment of the uranium rich slime pulp in a basket resin-in-pulp (RIP) circuit. The resin was eluted with a nitrate solution and uranium was precipitated with ammonia, filtered and dried.

The lime content of ores tributary to the Moab mill increased in the late 1950s, and acid costs became excessive. In 1961 the mill was converted to an alkaline-leach RIP process of approximately the same capacity.

In 1967, Atlas installed an acid leach, solvent extraction (SX) process to recover both uranium and vanadium. Shortly thereafter, Atlas modified the alkaline circuit to precipitate the uranium directly from a clarified leach liquor, thus abondoning the RIP operation which had become obsolete and expensive to operate. The combined capacity of the acid and alkaline circuits was about 1,000 tpd. A fire in December 1968 destroyed the SX circuits, and other general plant facilities, necessitating a mill shutdown of about six months.

After the Mexican Hat mill was shut down the circuit to recover byproduct copper from the copper-uranium ores, previously tributary to that mill, was moved to the Moab mill. Byproduct copper was recovered at Moab only intermittently, during the late 1960s, when sufficient ore had been stockpiled to make operation worthwhile. Eventually, those mines in southeast Utah that produced copper-uranium ores, such as the Happy Jack, were exhausted and the circuit was no longer used.

Atlas released neutralized effluent to the river during the early years of its operation. Beginning in the early 1960s, the effluent was treated for radium removal prior to discharge. That practice ended in July 1977, and since then no effluent has been released to the river. All excess process waters are now evaporated from ponds.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Atlas' Moab operation and mill production data during the term of the AEC contract.

Table 1 - AEC Purchases of U_3O_8 from Atlas Corp.-Moab, UT

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-266	1957[a]-1971[b]	38,500,282	8.07[c]

a) First U_3O_8 delivered 11/56.
b) Last U_3O_8 delivered 12/70.
c) Average Fiscal Year costs ranged from $5.72 to $8.86 per lb.

Table 2 - Mill Production Data - Atlas Corp.-Moab, UT

	AEC Contract
Period of Operation	10/56-12/70
Uranium Ore	
Fed to Process (Tons)	6,354,733[1/]
U_3O_8 (%)	0.34
U_3O_8 (Lbs.)	43,762,217
Production	
U_3O_8 in Conc. (Lbs.)	42,031,597[1/]
U_3O_8 Recovered (%)	96
U_3O_8 Shipped to AEC (Lbs.)	38,498,711
U_3O_8 Shipped to Others (Lbs.)	3,420,460
V_2O_5 Fused Oxide (Lbs.)	1,254,611[2/]

1/ AEC Production Data Book total. Atlas, for the Commingled Uranium Tailings Study (p. A-111), reported 6,393,389 tons ore fed and 41,477,839 lbs. U_3O_8 produced. Total ore fed start-up through CY 1981, was 10,165,000 tons (p. A-112).

2/ Vanadium circuit started June 1967, operated 18 months before being destroyed by a fire in December 1968. The circuit was rebuilt early in CY 1970 but there is no record of vanadium production during the remaining term of the AEC contract.

At the termination of the AEC contract, there were about 6.4 million dry tons of tailings impounded at the Moab millsite. These tailings occupied an area of 118 acres in one pile ranging from 0 to 75 feet in height. At the end of calendar year 1981, the tailings pile covered about 128 acres, was 4 to 100 feet in height, and contained about 10.1 million tons of solids.

No tailings have been released for use in the community or nearby areas, none have been reprocessed, and the extent of stabilization to date has been to cover the slopes with red sandstone and shale excavated nearby.

THE GALIGHER COMPANY AND NATIONAL LEAD COMPANY, INC.
Monticello, Utah

Contract No. AT(05-1)-53 was entered into by the AEC and The Galigher Company on August 23, 1949, initially for a term through September 30, 1950. Extensions of the contract carried its term through March 31, 1956.

Under the contract The Galigher Company took custody of the Monticello plant, which had been acquired by the AEC from the War Assets Administation on July 28, 1948, and managed and operated the plant for the recovery of uranium and vanadium from ore furnished to the contractor by the AEC. The contractor's function included construction and installation of additional buildings and facilities (in effect, the renovation of what had formerly been a vanadium processing plant), management of Government-owned housing for personnel working at the plant, analyses of results of metallurgical tests of ore to determine amenability to the Monticello plant flowsheet, and engineering development, design, and modification of the plant flowsheet. These functions were carried out pursuant to plans submitted to the AEC by the contractor and approved by the AEC.

On April 1, 1956, National Lead Company, Inc assumed operation of the Monticello processing plant and related facilities pursuant to a letter agreement with the AEC dated March 14, 1956. The letter agreement was superceded, effective April 1, 1956, by Contract No. AT(05-1)-699, which was executed on April 5, 1957. National Lead Company, Inc. continued the operation under the contract through January 15, 1960, when the mill was closed down.

Since all of the ore processed at the Monticello mill, as well as the facility itself, was owned by the Government, the AEC did not pay a "price" to the contractors for the uranium and vanadium concentrates produced in the mill. Instead, the contractors were paid for the costs of their operation of the mill and related facilities, plus negotiated fixed fees to compensate them for their managerial efforts.

As a function of its cost-type contract with the AEC, American Smelting and Refining Company (AS&R) acted as the AEC's ore buying agent and operated the Government-owned Monticello ore buying station and related weighing and sampling facilities from August 1948 until Lucius Pitkin, Inc. took over the operation on February 1, 1956. On September 1, 1956, National Lead Company, Inc. assumed the ore weighing, sampling, and stockpiling operations at Monticello, although Lucius Pitkin, Inc. continued to adminster ore purchase contracts, assay the samples, and make settlements for ore received. This practice continued until the shutdown of the mill in 1960, after which Lucius Pitkin, Inc. again assumed full operation of the ore buying station.

At the Monticello buying station the AEC purchased carnotite and roscoelite-type ores of the Colorado Plateau area under its Domestic Uranium Program Circulars 1, 3, and 4, and, later, Circulars 5 and 5, Revised. It also purchased, under specific ore purchase agreements, a wide variety of uranium ores which did not meet the specifications of circulars, thus providing a market for independent producers whose ore were not amenable to processing in any of the privately-owned mills to which they were tributary.

Most of the ore purchased at the buying station and processed in the Monticello mill came from small independent mining operations and from AEC leased lands in the Uravan Mineral Belt area of western Colorado and southeastern Utah. Ores were also shipped to the mill from other areas such as Red Canyon and White Canyon, the Henry Mountains, and the Big Indian Wash areas of southeastern Utah, and the Monument Valley area of Arizona.

After the mill was closed down in January of 1960, Lucius Pitkin, Inc. continued to operate the ore buying station for the AEC through March 31, 1962, the expiration date of Circular 5, Revised. Ore purchased during that period was sold by the AEC to private mill operators in the area.

The mill and buying station facilities have since been dismantled and the tailings site has been covered with rock and soil, and seeded to minimize wind and water erosion. The site, now under the jurisdiction of the Department of Energy, falls within the purview of the DOE's Surplus Facilities Management Program.

The Monticello millsite, at the time of shutdown and decommissioning in 1960, consisted of 192 acres. The site adjoins the small community of Monticello on the south and in part straddles South Creek, which traverses the site in a west to east direction. The site was initially selected by Vanadium Corporation of America (VCA) late in 1940 to establish an ore buying depot in an effort to stimulate vanadium mining and to build up an ore stockpile. It was thought that if sufficient ore were secured to justify the project, a mill could be built; otherwise, ore purchased could be shipped to VCA's Naturita (Colorado) plant for processing. Mining increased and ore receipts were sufficiently encouraging so that in September 1941, the War Production Board agreed that a 120 ton per day (tpd) mill should be built. The project was conducted under a lease agreement with the Defense Plant Corporation, which funded the $875,000 construction. The mill design and construction was handled by Stearns-Roger Manufacturing Company of Denver. Actual construction started in February and on August 24, 1942, the first vanadium was produced.

In April 1942, while construction was under way, the Metals Reserve Company (MRC) established an ore buying station at Monticello, and appointed the United States Vanadium Corporation as its buying agent. All ore producers, independents and VCA, then sold ore to the MRC. MRC in turn had the ore milled by VCA or other mills.

A substantial part of the early ore came from the Navajo Indian Reservation in Arizona and New Mexico. In milling, the carnotite ore (averaging about 1.8% V_2O_5) was mixed with iron pyrite, crushed, dried to 3 percent moisture, ground to minus 10-mesh, mixed with ordinary salt, roasted and leached with a soda ash (sodium carbonate) solution. Vanadium pentoxide (V_2O_5) was precipitated from the leach solution by the addition of sulfuric acid, and the precipitate was washed, dried, and then fused. Fused V_2O_5 was shipped east to be converted to ferrovanadium for use in making steel alloys.

Construction of the Monticello plant, in addition to the mill proper, included the development of an adequate water supply, installation of a power plant, and the construction of two large housing projects for workmen. The staff townsite, on the hill opposite the mill, consisted of a staff house for 12 men, a manager's house, and 14 4-room family dwellings. The other housing project consisted of a bunk and boarding house for 32 men and 32 2-room family houses.

Late in 1942 and early in 1943 the Manhattan Engineer District (MED) began a program to obtain uranium from domestic sources. In January 1943, VCA agreed to produce a uranium-vanadium (U-V) sludge at Monticello that was sold by MRC to MED on a unit price basis. The sludge contained 45 to 50% U_3O_8 and about 25% V_2O_5 and was shipped to the Vitro plant at Canonsburg, Pennsylvania, for additional processing. Tailings from the Monticello mill were considered by the MED to be too low in uranium for additional processing. In February 1944, MRC closed the Monticello mill and ceased production of both fused oxide (V_2O_5) and the U-V sludge.

In 1945 VCA leased the Monticello mill from the Defense Plant Corporation and purchased from MRC the remaining ore stockpiles. VCA processed the stockpiled ore, plus ore from other sources, and sold a U-V sludge to the MED until the mill closed again in 1946.

In July 1948 the AEC purchased the Monticello site from the War Assets Administration. The rehabilitation of the mill by The Galigher Co., described earlier in this report, was accomplished at a cost of $1,191,000. The redesigned mill, with a capacity of 100 tpd, consisted of two separate operations, the receiving, sampling and stockpiling of ore by AS&R and the processing of ores from these stockpiles by The Galigher Co. The mill flowsheet included a dry ore crushing and screening section, followed by salt roasting and quenching in hot sodium carbonate solution. After quenching the calcine was ground to natural grain size (approximately 65 mesh) and the uranium and vanadium were dissolved by agitation leaching at 200°F. Extractions of 93 percent of the uranium and 85 percent of the vanadium were obtained. The agitated pulp was thickened and then filtered and washed to separate solid tailings from the pregnant solution. The uranium was precipitated as a yellow cake (sodium uranyl vanadate) containing about 45% U_3O_8 and 17% V_2O_5. This cake was dried and fused at 1,650°F. with soda ash, salt, and sawdust, which reduced the uranium to an insoluble black oxide. Leaching of the fused cake separated the soluble vanadium. The uranium (black cake) was filtered, dried, and packaged for shipment. The dissolved vanadium was precipitated, filtered, dried, and fused.

Early operations of the Monticello mill by The Galigher Co. were complicated by the necessity to treat large tonnages of Temple Mountain asphaltic-type ore that was not amenable to the salt roast procedure, besides being low in vanadium content. This ore required a low temperature roast (1,020°F.) prior to leaching and even then only 80 to 85 percent of the uranium was extracted.

Changes in the types of ores received at Monticello prompted process changes in 1955. The existing carbonate leach plant was modified to eliminate the salt roast and vanadium recovery and expanded to increase the capacity to about 200 tpd. A new acid leach resin-in-pulp (RIP) plant was constructed and placed in operation in November 1955. This new 400 tpd plant was the first to use the RIP process that had been developed at the AEC's Grand Junction pilot plant.

Further changes in ore purchased at Monticello, particularly the deliveries of high-lime ores, necessitated abandonment of acid leaching. So, in 1958, pressure leaching vessels (autoclaves) and other equipment were installed and the mill was converted to an alkaline leach RIP process. Operation commenced on August 8, 1958 at a capacity of about 300 tpd and that process was used until the mill shut down in January 1960. The raw ore carbonate leach circuit was shut down when the alkaline leach RIP was started.

Table 1 presents data on the total U_3O_8 produced and delivered to the AEC from the Monticello mill. No data are available on uranium produced and sold to the MED during operations in the 1940s. Table 2 summarizes the Monticello mill production when the mill operated by The Galigher Co. and by National Lead, Inc., and for the life of the operation under AEC's contracts.

Table 1 - AEC Receipts of U_3O_8 from Monticello, Utah, Mill

Contract No.	Contractor	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-53	The Galigher Co.	1950[a]-1956	1,438,879	11.16
AT(05-1)-699	National Lead, Inc.	1956-1960[b]	3,144,149	9.36
Total		1950 - 1960	4,583,028	9.92[c]

a) First U_3O_8 delivered 1/50.
b) Last U_3O_8 delivered 1/60.
c) Average Fiscal Year costs ranged from $9.11 to $33.80.

Table 2 - Mill Production Data - AEC's Monticello, Utah, Mill

	AEC Contracts[1/]		
	The Galigher Co.	National Lead, Inc.	Total
Period of Operation	9/1/49-3/31/56	4/1/56-1/15/60	9/1/49-1/15/60
Uranium Ore			
Fed to Process (Tons)	318,242	585,056	903,298
U_3O_8 (%)	0.29	0.32	0.31
U_3O_8 (Lbs.)	1,839,439	3,709,255	5,548,694
Production			
U_3O_8 in Conc. (Lbs.)	1,438,879	3,144,149	4,583,028
U_3O_8 Recovered (%)	78	85	83
U_3O_8 Shipped to AEC (Lbs.)	1,438,879	3,144,149	4,583,028
U_3O_8 Shipped to Others (Lbs.)	0	0	0
V_2O_5 Shipped to AEC (Lbs.)[2/]	2,341,869	0	2,341,869

1/ These data are from USAEC Audit Report dated 6/13/63 and are considered more accurate than data in the AEC's Production Data Book. That book shows the total millfeed as 907,917 tons, averaging 0.306% U_3O_8, containing 5,556,440 lbs. U_3O_8, and production and shipments totaling 4,570,146 lbs. U_3O_8.

2/ Vanadium was recovered by Galigher during the period CY 1950-1956. V_2O_5 in fused oxide that was produced at Monticello was delivered the AEC at Grand Junction, and it amounted to about 8 percent of the total V_2O_5 purchased by the AEC.

The first extensive uranium mill tailings stabilization project was completed in 1962 by the AEC at the Monticello millsite. The estimated 903,000 tons of tailings in four separate areas covering about 40 acres, were graded to facilitate drainage, and covered with rock and soil to a depth of one to two feet. After fertilizing, grasses were sown and good vegetation cover was established.

After the dismantling of the mill buildings and stabilization of the tailings, part of the site, where garages and warehouses are located, was turned over by the AEC to another Government agency for its use.

Currently, approximately 72 acres of the millsite are still owned and maintained by the Department of Energy through its contractor, Bendix Field Engineering Corporation. The site is posted and enclosed with fences and locked gates.

Radiation surveys on the nearby community have shown some structures with higher than normal gamma radiation levels. All such structures were scheduled for additional on-site radiation surveys in 1982 to determine if the anomalous radiation could be attributable to the use of tailings from the mill.

VITRO CORPORATION OF AMERICA
Salt Lake City, Utah

Contract No. AT(49-1)-608 was entered into on October 25, 1951, with Vitro Corporation of America. It was replaced by Contract No. AT(05-1)-704, entered into on October 22, 1956, effective October 1, 1956 through March 31, 1962. This contract was replaced by Contract No. AT(05-1)-902, effective January 1, 1962 through December 31, 1963, with provision for extension to a date not later than December 31, 1966. The contract was terminated July 27, 1965, the last ore having been fed to process in December of 1963. Plant clean-up followed and the last U_3O_8 was delivered to the AEC in July 1964.

Under Contracts AT(49-1)-608 and AT(05-1)-704, and through March 31, 1962 under Contract No. AT(05-1)-902, the AEC paid negotiated prices for the U_3O_8 in concentrates. After March 31, 1962, the price was the fixed $8.00 per pound of U_3O_8 established by the AEC's May 24, 1956 announcement.

The mill operated essentially as a "custom" mill. Approximately 95 percent of its ore feed was obtained from independent ore producers and from AEC stockpiles, with about 5 percent furnished by Vitro.

Ore was received from a large number of individual mines located primarily in southeastern Utah, but also from other areas in the western United States. The AEC provided for the purchase of uranium ores in Salt Lake City during the period FY 1953-1958. A total of 34,988 tons of ore, averaging 0.33% U_3O_8, was purchased. The ore was sampled for the AEC under a contract with the Utah Ore Sampling Company, Murray, Utah, (15 miles from the mill) and then transported and stockpiled in a designated area of the Vitro millsite. This AEC ore, as well as ore from other AEC ore buying stations (a total of 163,824 tons), was sold to Vitro for processing at the Salt Lake City mill. Vitro also used the Utah Ore Sampling Company to sample other ore purchased by Vitro until late 1957 when an ore sampling plant was constructed at the millsite.

In 1951 Vitro purchased the Kalunite Plant of the J. R. Simplot Company in Salt Lake City, which had been built during World War II for producing alumina from Utah clays. Vitro converted the plant to process uranium ores at a rate of about 100 tons per day (tpd). The process consisted of sulfuric acid leaching, liquid-solids separation by countercurrent decantation, and chemical precipitation of a uranous phosphate product. The roasters in the original alumina plant were used for roasting uranium ores containing high concentrations of carbonaceous or organic material.

The mill capacity was gradually expanded, and by 1956 it could treat 500 tpd. In 1957, the capacity was further expanded to 600 tpd when a new solvent extraction (SX) circuit was brought on stream. The SX process was unique in that Vitro stripped the organic solvent with hydrochloric acid, enabling Vitro to recover small quantities of scandium as a byproduct of the uranium production. No other mill in the United States utilized the Vitro SX process.

As uranium production was phased out in late 1963 the mill facilities were converted for the production of vanadium from Idaho ferrophos, a waste product from elemental phosphorus production. This operation was conducted by Vitro until July 1968, when the mill was permanently shut down.

Mill demolition began in 1968 and was completed in 1970, except for a 450-foot stack, a water tank, and railroad spur. Unprocessed ore and radioactive soil removed during clean-up were shipped to other mills. The site is now inactive and has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the millsite and tailings is contained in the Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has a "high" priority for remedial action because of its location in the Salt Lake City metropolitan area.

Data on AEC purchases of U_3O_8 and mill production data are shown in Tables 1 and 2.

Table 1 - AEC Purchases of U_3O_8 from Vitro Corporation-Salt Lake City, UT

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(49-1)-608	1952[a]-1957	1,981,045	14.30
AT(05-1)-704	1957 - 1962	6,420,000	10.23
AT(05-1)-902	1962-1965[b]	1,173,454	8.04
Total	1952 - 1965	9,574,499	10.80[c]

a) First U_3O_8 delivered 10/51.
b) Last U_3O_8 delivered 7/64.
c) Average Fiscal Year costs ranged from $7.76 to $15.04.

Table 2 - Mill Production Data - Vitro Corporation-Salt Lake City, UT

	AEC Contracts
Period of Operation	5/51 - 1/64
Uranium Ore[1/]	
Fed to Process (Tons)	1,688,577
U_3O_8 (%)	0.32
U_3O_8 (Lbs.)	10,701,519
Production	
U_3O_8 in Conc. (Lbs.)	9,573,883
U_3O_8 Recovered (%)	89
U_3O_8 Shipped to AEC (Lbs.)	9,573,877
U_3O_8 Shipped to Others (Lbs.)	6

1/ Some ores received at Vitro during early operations contained appreciable vanadium and averaged 0.7% V_2O_5 during the three years FY 1953-1955, but there were no provisions for vanadium recovery during the AEC contract periods. Ores remaining after the mill was shut down (57,459 tons) were sold to Atlas at Moab, Utah.

During the period in which Vitro produced uranium concentrate for sale to the AEC the Salt Lake mill generated about 1.7 million tons of tailings. At present there are approximately 2.6 million tons of uranium and vanadium tailings occupying an area of 111 acres. The tailings areas were initially excavated to provide material for dikes, so the lower level of the tailings pile area is about four feet below the surrounding ground level, with the tailings ranging up to about 12 feet above the normal ground level. None of the tailings were reprocessed but apparently some have been removed from the site.

Field studies conducted by the Environmental Protection Agency, radiological scan surveys conducted by the Utah Department of Health, and aerial radiological surveys conducted by the Department of Energy have identified a number of privately-owned properties in the vicinity of the tailings sites as having anomalous radiation levels. As of April, 1981, 24 properties had been designated by the DOE for remedial action and clean-up already has been accomplished at some locations.

DAWN MINING COMPANY
Ford, Washington

Contract No. AT(05-1)-706 was entered into with Dawn Mining Company, a subsidiary of Newmont Mining Corporation, on August 8, 1956. The contract was replaced by Contract No. AT(05-1)-788, entered into on April 26, 1960, effective from March 1, 1960 through December 31, 1966, with provision for final delivery of concentrates by February 2, 1967.

Under Contract No. AT(05-1)-706, and under Contract No. AT(05-1)-788 in the period through March 31, 1962, the AEC paid a negotiated price for U_3O_8 in concentrates. Thereafter it paid a fixed price of $8.00 per pound of U_3O_8 in concentrates as established by the AEC's May 24, 1956 announcement.

Nearly all of the ore fed to process under the two contracts came from contractor-controlled sources, principally from the Midnite Mine, located about 22 road miles northwest of the mill on the Spokane Indian Reservation. Midnite Mines, Inc. was 60 percent controlled by Spokane Indian tribal members and had a 49 percent ownership interest in Dawn. Only a little more than seven percent of the millfeed was purchased from independent ore producers.

The mill ceased operation in mid-1965, prior to the expiration of Contract No. AT(05-1)-788 on December 31, 1966, although uranium concentrate deliveries to the AEC continued into December of 1966.

Dawn Mining Company resumed operation of the plant in late 1969 for production of uranium concentrates for sale in the commercial market, and the mill is currently operating.

The site of the mill is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Office and is contractor, Bendix Field Engineering Corporation, under Public Law 96-540. A detailed description of the millsite and tailings is contained in the Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

The Dawn millsite, consisting of about 500 acres, is located about one-half mile from the town of Ford, Washington, and about 25 miles northwest of Spokane.

The mill began operations in August 1957, with a nominal capacity of 440 tons per day (tpd). Dawn produced uranium concentrate for sale to the AEC until July of 1965 and stored excess concentrate for delivery during the remaining term of its contract. During that period the mill processed ore at a rate of about 500 tpd and treated a total of 1,171,315 tons of ore averaging 0.24% U_3O_8. Recovery averaged 96 percent. None of the uranium concentrate produced was delivered to others than the AEC during the period of the AEC contracts. All production after the mill resumed operations in late 1969 has been for private sales.

The milling process consisted of crushing, grinding, two-stage sulfuric acid leach, four-stage countercurrent decantation, pregnant solution clarification through an anthracite column, and ion exchange for uranium recovery (four columns), followed

by nitrate elution, two-stage precipitation with lime and ammonia, product thickening, and drying in a steam-heated dryer. The process remained unchanged until 1980, when installation of new ion exchange resin resulted in a change from nitrate to sulfate elution.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Dawn's Ford operation and mill production data during the term of the AEC contracts.

Table 1 - AEC Purchases of U_3O_8 from Dawn Mining Co.-Ford, WA

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-706	1958[a]-1960	1,510,477	10.81
AT(05-1)-788	1960-1967[b]	3,769,198	8.31
Total	1958 - 1967	5,279,675	9.03[c]

a) First U_3O_8 delivered 9/57.
b) Last U_3O_8 delivered 12/66.
c) Average Fiscal Year costs ranged from $8.00 to $10.96.

Table 2 - Mill Production Data - Dawn Mining Co.-Ford, WA

	AEC Contracts
Period of Operation	8/57-12/66
Uranium Ore	
Fed to Process (Tons)	1,171,315 1/
U_3O_8 (%)	0.24
U_3O_8 (Lbs.)	5,560,134
Production	
U_3O_8 in Conc. (Lbs.)	5,314,770
U_3O_8 Recovered (%)	96
U_3O_8 Shipped to AEC (Lbs.)	5,282,563
U_3O_8 Shipped to Others (Lbs.)	None
U_3O_8 Ending Inventory (Lbs.)	32,207 2/

1/ Mill preproduced U_3O_8 for sale to AEC and shut down in mid-1965. In late 1969 operations resumed for commercial sales of uranium. Through CY 1981 a total of 2,940,000 tons of ore had been fed to process (Commingled Uranium Tailings Study, p. A-126).

2/ Inventory of U_3O_8 in finished product at 1/1/67.

At the termination of the AEC's contractual arrangements with Dawn, there were about 1.2 million tons of tailings impounded at the Ford millsite. The tailings occupy an area of 59 acres and average about 10 feet in height. When it resumed operations in 1969, Dawn began tailings impoundment in an area separate from the area which contains tailings attributable to production of concentrates for the AEC and, in 1981, initiated lined subsurface disposal of tailings in yet another area. The "commercial" tailings areas, as of the end of calendar year 1981, contained a total of about 1.77 million tons of tailings averaging about 15 feet in depth.

The area of tailings attributable to production under the AEC contracts has been covered with 6 to 12 inches of wood chips, except for an area of about 10 acres which has been covered with about one foot of dirt. Most of the tailings in the area of "commercial" tailings have also been covered with one to three feet of dirt.

No tailings have been removed from the millsite area, which is fenced and has controlled access.

FEDERAL-RADOROCK-GAS HILLS PARTNERS
Gas Hills, Wyoming, Area

Contract No. AT(05-1)-760 was entered into and effective on April 10, 1959, for a term extending through December 31, 1966. The contract was rewritten by Modification No. 1, executed on January 28, 1965, effective January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 1 was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962.

Under the contract the AEC paid negotiated prices for the U_3O_8 in concentrate purchased through March 31, 1962. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, for uranium attributable to contractor-controlled ore, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs during the 1963-1968 period, as determined by an audit of mining and milling costs. In the same period (1969-1970) the AEC paid a fixed price of $6.70 per pound of U_3O_8 in concentrate attributable to ores purchased by the contractor from independent ore producers, as required by its November 17, 1962 announcement.

The mill's ore feed came largely (90 percent) from contractor-controlled mining properties in the Gas Hills, Wyoming area. The other 10 percent was obtained from independent ore producers in the area.

Federal-American Partners (FAP) (successor to Federal-Radorock-Gas Hills Partners) continued the mill operation after the AEC contract expired on December 31, 1970. In April 1973, the Tennessee Valley Authority leased the partnership properties and has a contractual first right to use the mill. Operation of the mill was suspended on October 31, 1981, and the mill is now in "standby."

The site is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 97-540. A detailed description of the millsite and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

Federal's Gas Hills mill is located on 20 acres of patented land about 50 miles east of Riverton, Wyoming, Fremont County. The mill began operation in October of 1959 with a nominal capacity of 580 tons per day (tpd), utilizing an acid leach followed by removal of the dissolved uranium from a slime pulp in a continuous countercurrent resin-in-pulp (RIP) circuit. In the original process an acidified ammonium nitrate solution was used for elution in the RIP circuit, and the eluate was neutralized to precipitate the uranium.

In 1964 the Eluex process, which combines RIP with solvent extraction, was installed. In the Eluex process sulfuric acid is used for elution of the resin in place of the nitrate solution. The uranium is extracted from the eluate in a solvent extraction circuit and most of the acid is returned to the resin elution circuit. The uranium is stripped from the organic solvent with ammonium sulfate and is precipitated with ammonia to produce a high grade (95 to 96 percent U_3O_8)

concentrate product. Concurrently with the addition of Eluex other leaching and RIP equipment was installed to expand the mill capacity to 950 tpd.

During the period of the AEC contract the mill processed ore at an average rate of about 800 tpd and treated a total of 2,676,315 tons of ore averaging 0.17% U_3O_8. Recovery averaged 92 percent. Of the U_3O_8 produced during the AEC contract period, 78 percent was delivered to the AEC and 22 percent was sold commercially. (Tonnage of ore fed includes 155,548 tons which Federal toll milled for Susquehanna-Western, Inc.; and the percentage delivered to the AEC includes the resulting 490,783 pounds of U_3O_8 in concentrate sold to the AEC by Susquehanna-Western under its Contract No. AT(05-1)-793). All production after June of 1969 was sold by Federal in the commercial market.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Federal's Gas Hills operation and mill production data during the term of the AEC contract.

Table 1 - AEC Purchases of U_3O_8 from Federal-American Partners - Gas Hill, WY

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-760	1960[a]-1969[b]	6,469,895	7.92[c]

a) First U_3O_8 delivered 12/59.
b) Last U_3O_8 delivered 6/69.
c) Average Fiscal Year costs ranged from $6.75 to $8.29.

Table 2 - Mill Production Data - Federal-American Partners-Gas Hills, WY

	AEC Contract
Period of Operation	10/59 - 12/70[1/]
Uranium Ore	
Fed to Process (Tons)	2,676,315[2/]
U_3O_8 (%)	0.17
U_3O_8 (Lbs.)	9,703,477
Production	
U_3O_8 in Conc. (Lbs.)	8,942,190[3/]
U_3O_8 Recovered (%)	92
U_3O_8 Shipped to AEC (Lbs.)	6,954,100[3/]
U_3O_8 Shipped to Others (Lbs.)	1,916,363
U_3O_8 Ending Inventory (1/1/71) (Lbs.)	71,727

1/ AEC contract term was through 12/70 but after 6/69, Federal sold its U_3O_8 production in the commercial market.

2/ AEC Production Data Book shows 2,520,767 tons ore fed; however, an additional 155,548 tons of ore was toll milled by FAP for Susquehanna-Western, Inc. (S-W) during FY 1964-1966.

3/ Included 490,783 lbs. U_3O_8 in concentrate produced and shipped for S-W which AEC purchased under Contract AT(05-1)-793.

At the termination of the AEC contract on December 31, 1970, there were about 2.7 million tons of tailings impounded in two separate tailings ponds covering a total of 85 acres, located on unpatented mining claims adjacent to the 20-acre millsite. Average depth of the tailings at that time was 40 feet.

As of December 31, 1981, the two ponds contained approximately 5.9 million tons of tailings covering a total of 117 acres to an average depth of 50 feet. The smaller of the two tailings areas (38.5 acres) contains tailings attributable solely to production of concentrates for sale to the AEC, while the larger pond (78.5 acres) contains a mixture of tailings from production both for AEC and commercial sales. Tons of tailings refers to weight of dry solids.

No tailings have been removed from the site and none have been reprocessed. Since the plant shutdown in 1981, water sprinklers have been placed on the tailings to keep the surface wet. A chemical stabilizer, Coherex, has been used in the past to cement the sands on the slopes of the piles. In 1981 the north faces of the dikes on both ponds were hydroseeded with a wheat grass and wood fibers, which has helped to control water and wind erosion.

A camp for mill and mine workers, consisting of about 20 structures and mobile homes about 1/2 mile from the mill, is being decommissioned.

GLOBE MINING COMPANY, GLOBE MINING CORPORATION, AND UNION CARBIDE CORPORATION
Gas Hills, Wyoming, Area

Contract No. AT(05-1)-745 was entered into with Globe Mining Company, a wholly-owned subsidiary of Union Carbide Corporation, on May 12, 1959, for a term extending through December 31, 1966, with provision for final concentrate deliveries through February 2, 1967.

Globe Mining Company changed its name to Globe Mining Corporation in November of 1963, and the contract was assigned by Globe Mining Corporation to Union Carbide Corporation on December 31, 1963.

Contract No. AT(05-1)-745 was rewritten as Modification No. 2, which was executed on May 13, 1964, effective January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 2 was negotiated pursuant to the AEC's "stretch-out" announcement of November 17, 1962.

Under the contract the AEC paid a negotiated price for U_3O_8 in concentrate purchased through March 31, 1962. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs during the 1963-1968 period, as determined by an audit of mining and milling costs. None of the uranium concentrate purchased by the AEC in the 1969-1970 period was attributable to ores purchased by the contractor from independent ore producers.

Practically all of the ore supply for the contractor's mill during the period of the contract was produced by contractor-controlled open pit mines in the Gas Hills area near the millsite. Only slightly more than two percent of the millfeed was purchased by the contractor from independent ore producers in the area. The mill also received and further refined a sizeable quantity of non-specification uranium concentrate from Union Carbide's Uravan mill and a small amount of yellow cake slurry from its in-situ leach facility in the Palangana Dome area of Texas.

Since the expiration of Contract No. AT(05-1)-745 Union Carbide Corporation has continued to operate its Gas Hills plant for the production of uranium concentrate for sale in the commercial market. The millsite is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed description of Gas Hills millsite and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

Union Carbide's Gas Hills plant, located about 50 miles southeast of Riverton, Wyoming, began operations in January of 1960. The mill had a nominal capacity of 500 tons per day. The process used included receiving, crushing, and fine ore storage; grinding; acid leaching; sand-slime separation; continuous counter-current resin-in-pulp (RIP); solvent extraction; precipitation; filtration, drying, and packaging; and tailings disposal.

From 1963 to 1966 the contractor ran an experimental heap-leach operation at the Gas Hills millsite, and in 1979 initiated a full-scale operation consisting of preparation of the heap-leach pads, circulation of sulfuric acid solution to attain the required buildup of uranium, and recovery of the uranium in the solvent extraction circuit.

In 1977, Union Carbide started sending uranyl carbonate solutions to the Gas Hills mill from a similar heap-leaching operation at Maybell, Colorado. The solutions are shipped by tank truck and enter the solvent extraction circuit of the mill.

The Gas Hills mill produced uranium for sale to the AEC from January of 1960 through December of 1970. During the period the mill processed ore at an average rate of 600 to 700 tons per day and treated a total of 2,463,809 tons of raw ore averaging 0.14% U_3O_8. During the contract period it also received and further refined non-specification uranium concentrate from Union Carbide's Uravan mill, containing 756,338 pounds of U_3O_8, yellow cake slurry from the Gas Hills experimental heap-leach operation containing 2,898 pounds of U_3O_8, and yellow cake slurry from its Palangana Dome, Texas, in-situ leach operation containing 2,972 pounds of U_3O_8. Recovery from the combined millfeed averaged 92 percent. Of the U_3O_8 produced through 1970, 77 percent was delivered to the AEC and 23 percent was sold commercially. All production since 1970 has been for private sales.

Tables 1 and 2 present data on AEC purchases from Union Carbide's Gas Hills operation and mill production data during the term of the AEC contract.

Table 1 - AEC Purchases of U_3O_8 from Union Carbide Corp.-Gas Hills, WY

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-745	1960[a]-1971[b]	5,617,289	7.69[c]

a) First U_3O_8 delivered 2/60.
b) Last U_3O_8 delivered 12/70.
c) Average Fiscal Year costs ranged from $5.37 to $8.39.

Table 2 - Mill Production Data - Union Carbide Corp.-Gas Hills, WY

	AEC Contract
Period of Operation	1/60 - 12/31/70
Uranium Ore	
Fed to Process (Tons)	2,463,809
U_3O_8 (%)	0.14
U_3O_8 (Lbs.)	7,131,888
Other Millfeed (U_3O_8 Lbs.)	
Heap Leach	2,898 1/
Uravan U_3O_8 Concentrate	756,338 2/
Material from Texas (Palangana)	2,972 2/
Total Millfeed (U_3O_8 Lbs.)	7,894,096
Production	
U_3O_8 in Conc. (Lbs.)	7,328,678
U_3O_8 Recovered (%)	93
U_3O_8 Shipped to AEC (Lbs.)	5,601,615
U_3O_8 Shipped to Others (Lbs.)	1,717,309
U_3O_8 Ending Inventory (Lbs.)	9,754

1/ Transfers of non-specification finished product from the Uravan mill for further refinement.

2/ Fed to process in November and December 1970.

At the termination of the AEC contract, there were about 2.5 million tons of tailings at the Gas Hills site, occupying an area of 60 acres. About 2.1 million tons of those tailings are attributable to uranium production for sale to the AEC and the remaining 0.4 million tons are attributable to production for commercial sales during the period of the AEC contracts. At the end of calendar year 1981, that tailings pile contained a total of about 6.4 million tons, occupying 146 acres. At the end of the AEC contract period the height of the tailings pile ranged from 0 to 40 feet and, as of the end of 1981, ranged from 0 to 50 feet. As of December 31, 1981, an additional 0.8 million tons of tailings, all from commercial production, were contained in separate piles.

No tailings have been released for use outside the millsite area. Some interim tailings stabilization has been done, using waste material to minimize radiation and blowing of sands.

LUCKY MC URANIUM CORPORATION AND UTAH CONSTRUCTION & MINING COMPANY
Gas Hills, Wyoming, Area

Contract No. AT(05-1)-710 was entered into on November 15, 1956, with Lucky Mc Uranium Corporation. That contract was replaced by Contract No. AT(05-1)-769, entered into on May 1, 1959 and effective from July 1, 1959 through December 31, 1966. Contract No. AT(05-1)-769 was rewritten as Modification No. 2, executed on July 2, 1964, effective January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 2 was entered into with Utah Construction & Mining Co., which had acquired Lucky Mc Uranium Corporation, and had assumed its rights and obligations under the contract as of December 19, 1960. The modification was negotiated pursuant to the AEC's "stretchout" announcement of November 17, 1962.

Under Contract No. AT(05-1)-710, and in the period of Contract No. AT(05-1)-769 prior to April 1, 1962, the AEC paid negotiated prices for the U_3O_8 in concentrate. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs during the 1963-1968 period, as determined by an audit of mining and milling costs. None of the concentrate purchased by the AEC in the 1969-1970 period was derived from independent ore production.

During the contract period, ores for the mill came from mines, primarily open pit operations, in the Gas Hills area of Wyoming, although a portion of the ore came from an underground mine in the Shirley Basin. The mill also received mine water from the Gas Hills area, and leaching solution from heap leach operations at the millsite, a uranium yellow cake slurry produced by in-situ leaching of ores located in the Shirley Basin. Eighty-seven percent of the ore fed to process during the contract period was mined from contractor-controlled properties and 13 percent was purchased from independent producers.

Since the expiration of Contract No. AT(05-1)-769 the mill has continued to operate for the production of uranium concentrates for sale in the private market. The present operator is Pathfinder Mines Corporation, a subsidiary of Utah International, Inc. In April, 1982 Utah International, Inc. announced completion of the sale of 80 percent of the stock of Pathfinder to a United States subsidiary of Compagnie Generale Des Matieres Nucleaires (Cogema). The millsite is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed study of the millsite and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

The Lucky Mc (now Pathfinder) millsite, consisting of approximately 900 acres, is located about 50 miles west of Casper, Wyoming. The mill began operations in February of 1958 with a nominal capacity of 750 tons per day (tpd). It produced uranium for sale to the AEC through December 31, 1970. During that period the mill processed ore at an average rate of about 800 tpd and treated a total of 3,484,556

tons of ore averaging 0.31% U_3O_8, plus other millfeed (in-situ leach product, heap leach product, and mine water) containing 1,675,992 pounds of U_3O_8. Recovery from the combined millfeed averaged 95 percent. Of the U_3O_8 production in the plant through 1970, 76 percent was delivered to the AEC and 24 percent was sold commercially.

The process initially used at the Lucky Mc mill included ore handling; crushing, drying, and sampling; grinding and classifying; two-stage acid leaching; counter-current decantation; solution clarification; ion exchange; precipitation; filtering and drying; packaging and shipping; and tailings disposal. It was the first mill in the United States to utilize the moving-bed ion exchange technique originally developed in South Africa.

In 1967 the mill was converted to the Eluex process by adding a solvent extraction circuit to further purify the ion exchange eluate prior to precipitation, and the capacity of the mill was increased to about 1,200 tpd.

In 1978 a semiautogenous grinding circuit replaced the original crushing and grinding operations, and in 1979 a resin-in-pulp circuit was added to operate in parallel with the column ion exchange circuit. These changes expanded the mill capacity to 2,800 tpd.

During the 1963-1970 period Utah Construction & Mining Company produced uranium solutions by in-situ leaching ore at its mining property in Shirley Basin, Wyoming. The uranium was extracted in an ion exchange plant near the mine site, where the uranium was precipitated from the eluate. The thickened concentrate was then shipped to the mill, where it was added into the precipitation circuit. During the period March 1963 through September 1964, the company also produced U_3O_8 from mine waters at its Gas Hills mine, and fed it to the precipitation circuit of the mill.

In the summer seasons between June of 1959 and October of 1962 the company heap leached low grade material at the millsite, using barren solutions from ion exchange as the leaching agent. The leached uranium was sent to the mill's ion exchange circuit for further processing.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from the Lucky Mc-Utah Construction & Mining Company Gas Hills operation and mill production data during the term of the AEC contracts.

Table 1 - AEC Purchases of U_3O_8 from Lucky Mc Uranium Corp.(Utah C&M Co.)-Gas Hills, WY

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-710	1958[a]-1959	2,183,220	8.99
AT(05-1)-769	1960-1971[b]	14,564,982[c]	7.59
Total	1958 - 1971	16,748,202[c]	7.76[d]

a) First U_3O_8 delivered 3/58.
b) Last U_3O_8 delivered 12/70.
c) Includes 97,943 lbs. U_3O_8 produced by Petrotomics for Utah and sold to AEC under Contract 769.
d) Average Fiscal Year costs ranged from $5.00 to $9.48.

Table 2 - Mill Production Data - Lucky Mc Mill, Gas Hills, WY

	AEC Contract
Period of Operation	2/58 - 12/70
Uranium Ore	
Fed to Process (Tons)	3,484,556[1/]
U_3O_8 (%)	0.31
U_3O_8 (Lbs.)	21,500,217
Other Millfeed (U_3O_8 Lbs.)	
Shirley Basin In-Situ Leach Production	1,490,433
Gas Hills Mine Water	34,432
Heap Leach at Millsite	151,127
Total Other Millfeed	1,675,992
Total Millfeed (U_3O_8 Lbs.)	23,176,209[2/]
Production	
U_3O_8 in Conc. (Lbs.)	21,912,119
U_3O_8 Recovered (%)	95
U_3O_8 Shipped to AEC (Lbs.)	16,650,868[3/]
U_3O_8 Shipped to Others (Lbs.)	5,081,281
U_3O_8 Ending Inventory (Lbs.)	179,970

1/ Total given in Commingled Uranium Tailings Study was 3,489,000 tons fed.

2/ Total adjusted for in-plant inventory changes was 23,135,017 lbs.

3/ Excludes the 97,943 lbs. U_3O_8 produced by Petrotomics for Utah and delivered under Contract 769.

At the termination of the AEC contracts period there were about 3.5 million tons of tailings, impounded at the site in two tailings areas. Also there were 260,000 tons of heap leach residues in an area near the mill. At the end of calendar year 1981 the two tailings piles contained a total of approximately 8.2 million tons of tailings, covering 97 acres to an average depth of 32 feet. The tailings in these two piles are attributable in part to uranium concentrate production for sale to the AEC and in part to production for commercial sales. As of December 31, 1981, a third disposal area of 151 acres, which began receiving tailings in March of 1980, contained an additional 1.3 million tons of tailings, all attributable to production for commercial sales. Two tailings solution ponds cover an additional 224 acres, but no solid tailings are impounded in them. About 168,000 tons of heap leach residues covering about 3 acres remained near the mill at the end of 1981.

The mill is currently operating and stabilization of tailings has not been undertaken. Only one tailings area, covering 53 acres, is totally inactive and is the only disposal area having an exposed, dry surface. A gypsum cement, which forms when the surface of the tailings becomes dry, provides a crust and minimizes the problem of windblown particulate matter. No tailings have been removed from the millsite.

FREMONT MINERALS, INC. AND SUSQUEHANNA-WESTERN, INC.
Riverton, Wyoming

Contract No. AT(05-1)-744 was entered into with Fremont Minerals, Inc. (a subsidiary of Susquehanna-Western, Inc.) on December 4, 1957. The contract was replaced by Contract No. AT(05-1)-793, which was entered into on January 4, 1961, effective June 1, 1960, with Susquehanna-Western, Inc. The term of Contract No. AT(05-1)-793 extended through December 31, 1966, with provision for final deliveries of concentrate through February 2, 1967.

Under Contract No. AT(05-1)-744, and through March 31, 1962 under Contract No. AT(05-1)-793, the AEC paid negotiated prices for the U_3O_8 in concentrate. Thereafter it paid the fixed price of $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement.

The Riverton processing plant ceased operation in May of 1963. After that date Susquehanna-Western, Inc. shipped its ore to the Federal mill in the Gas Hills, Wyoming, area and arranged for its purchased ores to be delivered to that mill for processing. The AEC continued to purchase the resulting concentrates under the Susquehanna-Western contract until July of 1965, when deliveries ceased.

Millfeed for the Riverton plant, and the ores which were tolled through the Federal plant, came primarily from the Gas Hills area of Wyoming. About 80 percent of the ore processed in both plants for sale of concentrates to the AEC under the Fremont Minerals and Susquehanna-Western contracts came from independent ore producers. Some 15 percent of the ore was purchased from the AEC, and about 5 percent was mined from contractor-controlled sources.

During the period March 1, 1955 to late 1957 the AEC operated a uranium ore buying station at Riverton which was located about one mile from the millsite. The AEC received and purchased 152,701 tons of ore averaging 0.23% U_3O_8. This ore was sold to Fremont Minerals for processing in its Riverton mill.

The AEC originally leased the buying station site from the Chicago and North Western Railway Company in November of 1954. At the end of November 1958, the AEC lease was terminated and Fremont Minerals took control of the site under a lease from the railway company and subleased to the AEC the portion of the site on which the AEC's ore handling facilities were located, so that the AEC's facilities, then excess to its needs, could remain on the property until the AEC could make arrangements to dispose of them. By April 1, 1960, disposal arrangements had been completed and the AEC facilities and equipment had been removed, and the sublease was terminated as of that date.

After Contract No. AT(05-1)-793 expired the mill was dismantled and most of the mill equipment and some of the structures removed. The site has been designated and assigned a "high" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the Riverton millsite and tailings area is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011).

The Riverton millsite, consisting of 112 acres, is located 2 miles southwest of Riverton in Fremont County, Wyoming. The site is in the Wind River valley on the Wind River Indian Reservation. The land around the site is generally flat and gently sloping ranchland. Portions of the main mill building, a water tower and an operable sulfuric acid plant, plus the tailings, remain on the site. The 900,000 tons of tailings occupy a rectangular area, about 500 feet south of the mill, of approximately 72 acres and have an average depth of 7.5 feet. The site is posted and fenced with barbed wire.

The Riverton mill was constructed as a custom mill to provide a market for the many ore producers in the Gas Hills, Pryor Mountains, and Riverton area. Because of the large number of ore shippers and the varied types of ore, the milling process had to be flexible to efficiently process virtually all types of ores in the district. Accordingly, the Riverton mill was a "two-circuit mill" with both acid and carbonate leach. Additionally, the company erected a 100 ton per day sulfuric acid plant at the mill in order to take care of its own acid requirements and the requirements of other operating mills in western Wyoming.

The Riverton mill operated for only four and one-half years. It had a nominal total capacity of 500 tons of ore per day (tpd); however, the acid section was capable of treating up to 600 tpd while the carbonate plant could process up to 300 tpd. During its operating life the mill averaged close to 600 tpd. Most of the ore was processed in the acid circuit because much less high lime ore was received than originally anticipated. The high lime ore (20 to 65% $CaCO_3$) was stockpiled and campaigned periodically through the carbonate plant. The average grade of ore processed at Riverton was 0.20% U_3O_8, from which 92 percent of the uranium was recovered. All uranium concentrate produced was sold to the AEC.

The milling process consisted of crushing and storage in fine ore bins that could be used to feed either the acid or carbonate leach circuits. The acid leach plant consisted of grinding, agitation leach with sulfuric acid and sodium chlorate, and liquid-solids separation by means of cyclones and a four-stage thickener (countercurrent decantation) circuit. Uranium was recovered from solution by solvent extraction.

The carbonate or alkaline leach plant consisted of grinding, thickening, and sodium carbonate-bicarbonate leach in open Pachuca tanks for a period of 54 hours. A temperature of 180°F. was maintained with steam, and air was added for oxidation. Three stages of drum filters were used to separate and wash the solids (tailings). The pregnant solution was clarified through a precoat filter and uranium was precipitated by addition of caustic. The uranium concentrate was filtered, dried, and packaged, while the barren solution was recarbonated in a tower 7 feet square and 52 feet high by use of waste CO_2 boiler flue gas.

Table 1 presents data on AEC purchases of U_3O_8 from Susquehanna-Western, Inc. Not all the U_3O_8 purchased was produced at the Riverton mill. After the Riverton mill shut down, the contractor arranged to have its ore toll milled at the Federal American Partners (FAP) mill in the Gas Hills area. A total of 490,783 pounds U_3O_8 in concentrate was produced by FAP and delivered to the AEC for Susquehanna-Western.

Table 1 - AEC Purchases of U_3O_8 from Susquehanna-Western, Inc.-Riverton, WY

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-744	1959[a]-1960	1,201,102	8.86
AT(05-1)-793	1960-1966[b]	2,690,135	8.36
Total	1959 - 1966	3,891,237	8.51[c]

a) First U_3O_8 delivered 1/59.
b) Last U_3O_8 delivered 7/65.
c) Average Fiscal Year costs ranged from $8.00 to $8.97.

Table 2 shows mill production data for the period of time the Riverton mill operated. Further explanation of the toll milling arrangement with FAP is given in the table footnote.

Table 2 - Mill Production Data - Susquehanna-Western, Inc.-Riverton, WY

	AEC Contracts
Period of Operation	11/58-5/63
Uranium Ore	
Fed to Process (Tons)	909,203[1/]
U_3O_8 (%)	0.20
U_3O_8 (Lbs.)	3,697,685
Production	
U_3O_8 in Conc. (Lbs.)	3,400,454
U_3O_8 Recovered (%)	92
U_3O_8 Shipped to AEC (Lbs.)	3,400,454
U_3O_8 Shipped to Others (Lbs.)	0

1/ Last ore fed to process in April 1963 and last U_3O_8 concentrate produced in May 1963. The Riverton mill was shut down in June 1963. After that an additional 155,548 tons of ore containing 527,507 lbs. U_3O_8 were tolled through the Federal-American Partners (FAP) mill during FY 1964-1966. FAP produced 490,783 lbs. U_3O_8 from the S-W ore, which were purchased by the AEC under Contract No. AT(05-1)-793. The tolled S-W ore consisted of 24,346 tons in stockpile at Riverton on 7/1/63 plus 131,202 tons actually received and stockpiled at the FAP mill.

The 72 acre tailings pile has been stabilized against wind and water erosion by a 1.5-foot cover of pit-run sand and gravel. Also, an estimated 94,000 cubic yards of clay material were used to seal the bottom of the tailings area prior to placement of the tailings.

As noted earlier, the millsite and tailings are located on the Wind River Indian Reservation. Some time after the mill shut down, the property was acquired by Solution Engineering Company of Alice, Texas, with a view toward extracting residual uranium from the tailings. The current owner of the site property is Lome Drilling and Well Service, Inc. The sulfuric acid plant is operated under lease by Western Nuclear, Inc.

Gamma radiation surveys in the Riverton area have detected about 30 anomalous properties. More detailed ground radiological survey work is scheduled by the DOE to determine if remedial action will be required at any of the vicinity properties.

PETROTOMICS COMPANY
Shirley Basin, Wyoming, Area

Contract No. AT(05-1)-790 was entered into on August 12, 1960, effective April 1, 1960, with Petrotomics Company, a general partnership consisting of Kerr-McGee Oil Industries, Inc., Tidewater Oil Company, Skelly Oil Company, and Getty Oil Company. The term of the contract extended through December 31, 1966, with provision for final concentrate deliveries through February 2, 1967.

The contract was designed to provide Petrotomics a market for its Shirley Basin ores (and ores which it might purchase) within limits specified in the contract. Petrotomics was not required to construct a uranium ore processing plant, but had the option to do so for the production of uranium concentrate for sale to the AEC after March 31, 1962. In the period prior to April 1, 1962, as to ore produced by Petrotomics, the AEC had the option of directing the contractor to deliver such ore to existing Wyoming mills or to stockpile it at Petrotomics' mine site on behalf of the AEC. For ore delivered by Petrotomics to other mills, it would receive from the milling companies prices prescribed by AEC 's Domestic Uranium Program Circular 5, Revised. For ore stockpiled for the AEC, Petrotomics would receive 90 percent advance payments from the AEC, again based on DUP Circular 5, Revised, with final settlement to be made by the AEC as such ore was received, sampled, and assayed by other mills to which it had been directed by the AEC. Petrotomics would refund to the AEC any of the advance payments received with respect to ores retained by the company as of April 1, 1962.

Considerable quantities of Petrotomics ore were purchased by the AEC under this arrangement. Part of this stockpiled ore was sold by the AEC to Western Nuclear Corporation and Federal-Radorock Gas Hills Partners in the pre-April 1, 1962 period, and further quantities were sold to Cotter Corporation by the AEC in the period after March 31, 1962.

Petrotomics opted to construct its own mill in the Shirley Basin, about 48 miles south of Casper, Wyoming, and sold uranium concentrates to the AEC in the period April 1, 1962 through December 31, 1966 at the fixed price of $8.00 per pound of U_3O_8 established by the AEC's May 24, 1956 announcement.

During the period of the contract prior to April 1, 1962, all of the ore sold by the contractor to the AEC, and additional ore stockpiled by the contractor, was produced by Petrotomics from its Shirley Basin properties. In the period after March 31, 1962, essentially all of the ore supply for the Petrotomics mill continued to come from Petrotomics properties, and only about three-tenths of one percent was purchased from independent producers in the area.

In addition processing ores for the production of uranium concentrate under Contract No. AT(05-1)-790, Petrotomics also produced 97,943 pounds of U_3O_8 in concentrate from ores furnished by Utah Construction & Mining Company. This concentrate was sold to the AEC by Utah under its Contract No. AT(05-1)-769.

After expiration of Contract No. AT(05-1)-790, the Petrotomics mill continued to operate for the production of uranium concentrate for sale in the commercial market. The mill was closed for a period from October 1974, to March 1978, but

is currently being operated by Getty Oil Company, which through merger and acquisition processes has succeeded to the ownership rights of the other former Petrotomics partners. The millsite is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public 96-540. A detailed description of the millsite and tailings is contained in the report, Commingled Uranium Tailings Study, DOE/DP-0011, Volume II, June 30, 1982.

The Petrotomics mill began operations in April 1962, with a nominal capacity of 500 tpd and treated a total of 786,928 tons of ore (including 21,989 tons which it processed for Utah Construction & Mining Company) averaging 0.24% U_3O_8. Millfeed during the AEC contract period also included uranium liquors, containing 28,778 pounds of U_3O_8, which were produced in Petrotomics' on-site heap leaching facility and fed into the solvent extraction circuit of the mill. Recovery from the combined millfeed averaged 96 percent. No deliveries of uranium concentrate were made in the commercial market during the period of the AEC contract.

The mill process included crushing and fine ore storage; grinding; acid leaching; countercurrent decantation washing; clarification of pregnant liquor; solvent extraction; precipitation and filtration; drying and packaging; and tailings disposal. The mill capacity was expanded in 1968 to 1,000 tpd by the addition of three 80-foot-diameter thickeners, leach tanks, and another solvent extraction circuit. In 1970, the mill capacity was expanded again to a capacity of 1,500 tpd. The process remained unchanged.

Beginning in 1966, through 1974, Petrotomics operated a heap leach facility at the millsite. Low grade material was placed to form a 25-foot-high pile with the top shaped into 40-foot-square paddies separated by ore berms. Acidified raffinate was put into the paddies and allowed to percolate down through the material. Pipes buried beneath the pile collected the solutions and sent them either to low grade sumps for recirculation through the piles or to high grade sumps for pumping to the plant solvent extraction circuit.

The residues from the heap leaching operation were fed to process in the mill during 1978 and 1979, and now reside within the tailings pond area.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Petrotomics' Shirley Basin operation and mill production data during the term of the AEC contract.

Table 1 - AEC Purchases of U_3O_8 from Petrotomics Co.-Shirley Basin, WY

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-790	1962[a]-1967[b]	3,383,821	8.00[c]

a) First U_3O_8 delivered 4/62.
b) Last U_3O_8 delivered 10/66.
c) All U_3O_8 purchases at a cost of $8.00 per lb.

Table 2 - Mill Production Data - Petrotomics Co.-Shirley Basin, WY

	AEC Contracts
Period of Operation	4/5/62 - 12/31/66
Uranium Ore	
Fed to Process (Tons)	786,928[1/]
U_3O_8 (%)	0.24
U_3O_8 (Lbs.)	3,778,418
Other Millfeed	
U_3O_8 (Lbs.)	28,778[2/]
Total Millfeed	
U_3O_8 (Lbs.)	3,807,196[1/]
Production	
U_3O_8 in Conc. (Lbs.)	3,672,925[1/]
U_3O_8 Recovered (%)	96
U_3O_8 Shipped to AEC (Lbs.)	3,383,854
U_3O_8 Shipped to Others (Lbs.)	0
U_3O_8 Ending Inventory (Lbs.)	191,143

1/ Millfeed includes 21,989 tons of ore containing 101,932 lbs. U_3O_8 that were processed for Utah Construction & Mining Company in FY 1965, from which 97,943 lbs. of U_3O_8 in concentrate were produced and are included in the production.

2/ Uranium from on-site heap leaching, solution added to SX circuit.

At the termination of the AEC contract, there were about 787,000 tons of tailings impounded at the Shirley Basin site. About 746,000 tons of the tailings were attributable to production of concentrate for sale to the AEC (including that produced for Utah C & M), and the remaining 41,000 tons were attributable to concentrate production held in inventory at the end of the AEC contract period and later sold by Petrotomics in the commercial market. The tailings covered an area of 50 acres to a height of 5.5 feet.

As of the end of calendar year 1981, about 5.5 million tons of tailings were impounded at the site, covering an area of 140 acres to a height of 35 feet.

No tailings have been removed from the site and none have been reprocessed. The tailings storage area is still in use and no permanent stabilization measures have been undertaken, although the tailings are sprinkled in the summer to increase evaporation and to form a crust which prevents spreading of the tailings by the wind.

LOST CREEK OIL AND URANIUM COMPANY, WESTERN NUCLEAR CORPORATION, & WESTERN NUCLEAR, INC.
Split Rock, Wyoming

Contract No. AT(05-1)-709 was entered into with Lost Creek Oil and Uranium Company on August 10, 1956, for a term extending through March 31, 1962. That contract was replaced by Contract No. AT(05-1)-765, executed on February 26, 1959, effective from June 30, 1959 through December 31, 1966, with provision for final concentrate deliveries through February 2, 1967. When this contract was signed the contractor had changed its name to Western Nuclear Corporation.

Contract No. AT(05-1)-765 was rewritten as Modification No. 3, which was executed on March 13, 1964, effective January 1, 1963, to extend the term of the contract through December 31, 1970, with provision for final concentrate deliveries through February 5, 1971. Modification No. 3 was negotiated pursuant to the AEC's "stretch-out" announcement of November 17, 1962. The modification was entered into with Western Nuclear, Inc., which had succeeded Western Nuclear Corporation in 1959.

Under the contracts the AEC paid negotiated prices for the U_3O_8 in concentrate purchased through March 31, 1962. In the period April 1, 1962 through December 31, 1968, the price was the fixed $8.00 per pound of U_3O_8 in concentrate established by the AEC's May 24, 1956 announcement and continued in effect through 1968 by the November 17, 1962 announcement. In the period January 1, 1969 through December 31, 1970, for uranium attributable to contractor-controlled ore sources, the AEC paid a negotiated price for U_3O_8 in concentrate, based on the contractor's production costs during the 1963-1968 period, as determined by an audit of mining and milling costs. In the same period (1969-1970) the AEC paid a fixed price of $6.70 per pound of U_3O_8 in concentrate attributable to ores purchased by the contractor from independent ore producers, as required by its November 17, 1962 announcement.

The principal sources of millfeed for the Split Rock mill were mines, mostly open pit operations, in the Gas Hills and underground operations in the Crooks Gap areas of Wyoming. In addition to feeding raw ore to the mill, the contractor shipped upgraded products from heap-leaching and ion exchange operations in the Gas Hills area and from its Spook concentrator in Converse County, Wyoming, for final processing through the Split Rock plant. Sixty-nine percent of the total millfeed during the contract term was derived from company-controlled properties. Twenty-nine percent was purchased from independent ore producers, and two percent was acquired from the AEC.

During the period from December 1956 until mid-1957, the AEC operated a provisional ore buying facility at Western Nuclear's Split Rock site. The provisional facility, which was located on land subleased by the AEC from Western Nuclear, had no sampling capability so the AEC made partial payments for the purchased ores, based on hand sampling, until Western Nuclear completed the permanent sampling plant which it was building in conjunction with the Split Rock mill. The AEC then leased the sampling plant from Western Nuclear in order to reweigh, mechanically sample, assay, and make final payment for the ores which it had received at Split Rock. Under these arrangements the AEC purchased 68,271 tons of ore averaging 0.20% U_3O_8. All of the ore was ultimately bought from the AEC by Western Nuclear and milled for the production of uranium concentrate for sale to the AEC.

After the expiration of Contract No. AT(05-1)-765, Western Nuclear, Inc. continued to operate the Split Rock plant for production of uranium concentrate for sale in the commercial market. The millsite is one of those studied under the Commingled Uranium Tailings Study conducted by the DOE's Grand Junction Area Office and its contractor, Bendix Field Engineering Corporation, pursuant to Public Law 96-540. A detailed study of the Split Rock millsite and tailings is contained in the report, Commingled Uranium Tailings Study (DOE/DP-0011, Volume II, June 30, 1982. The study also includes information regarding the Day-Loma and Bull Rush heap leach sites in the Gas Hills area and the Green Mountain ion exchange plant site in the Crooks Gap area.

The Spook concentrator facility, located about 40 miles northwest of Casper, Wyoming, has been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978. A detailed description of the Spook site is contained in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The operations at the Spook concentrator are also discussed under the section of this report entitled "Other Uranium Processing Plants."

The Split Rock millsite, consisting of approximately 237 acres, is located about 2 miles north of Jeffrey City and about 40 miles southeast of Riverton, Wyoming. The mill began operations in June of 1957 with a nominal capacity of 400 tons per day (tpd). It produced uranium for sale to the AEC through mid-1969. During the period of the AEC contracts, ending December 31, 1970, the mill processed ore at an average rate of about 1,000 tpd and treated a total of 4,004,282 tons of ore averaging 0.23% U_3O_8, plus other millfeed (heap leach and mine water products and Spook concentrator slurry) containing 436,692 pounds of U_3O_8. Recovery from the combined millfeed averaged 93 percent. Of the U_3O_8 produced through December 31, 1970, 84 percent was delivered to the AEC and 16 percent was sold commercially. All deliveries after June of 1969 were made to the commercial market.

The milling operation was curtailed in June of 1981, and the mill has since been used only for final processing of precipitated slurry from Western Nuclear's Green Mountain ion exchange facility.

The milling process initially used at Split Rock included receiving, crushing, sampling, and stockpiling; grinding and classifying; acid leaching; sand-slime separation; basket resin-in-pulp (RIP) ion exchange; eluate clarification; precipitation, thickening, filtering, drying, and packaging; and tailings sampling and disposal.

Expansion of the plant capacity in 1959 required additions in the grinding, leaching, sand-slime separation, and RIP circuits. An ore dryer was installed to prevent freezing of wet ore in the fine ore bins. Continuous precipitation and product drying processes were installed in place of the original batch processes. Capacity was increased from 400 to 1,000 tpd. In the spring of 1965 a solvent extraction circuit was added to effect savings in reagent costs by the use of the Eluex process.

A sulfuric acid plant was built in 1962 to provide the mill's requirements. Excess sulfuric acid was sold to other milling companies in the area.

Late in 1966 the basket RIP circuit was removed and replaced with a continuous countercurrent RIP process, and the entire product filtration circuit, consisting of vacuum drum filters and related equipment, was removed and replaced with a continuous centrifuge. A molybdenum circuit was installed in 1966, but was never used. Later, a carbon circuit was installed to treat the pregnant strip solution, but it also was never used.

Early in 1974 Western Nuclear shut down the mill to replace the ore buying, crushing, storage, and grinding equipment with a cascade mill and pulp storage tanks. The mill renewed operation in late 1975 and attained its new nominal capacity of 1,700 tpd in 1977.

Western Nuclear operated heap leaching facilities at its Bull Rush and Day-Loma properties in the Gas Hills area, and an ion exchange facility at its Rox mine, also in the Gas Hills area. It still operates an ion exchange plant in the Green Mountains, about 12 miles south of the Split Rock mill.

The Bull Rush operation consisted of preparation of the leach pads, circulation of sulfuric acid solutions to attain the required buildup of uranium, and hauling the pregnant solution to the Split Rock mill for final processing. The Day-Loma process was similar, except that in 1966 a solvent extraction circuit was added, in which sodium carbonate was used as a stripping agent. The pregnant strip solution was then sent to the mill for final processing.

The Green Mountain ion exchange plant recovers natural uranium from mine waters in the Crooks Gap area. Drainage from several mines is collected in a pond, then pumped through columns where the uranium is loaded onto resin. The uranium is stripped from the resin with sodium chloride-sodium bicarbonate solutions and precipitated as magnesium diuranate. The precipitated slurry is then shipped to the Split Rock mill for final processing. The Rox mine ion exchange plant used a similar process except that the loaded resin was shipped to the mill for stripping, as no chemicals were used in the process at the Rox mine site.

Tables 1 and 2 present data on AEC purchases of U_3O_8 from Western Nuclear's Split Rock operation and mill production data during the term of the AEC contracts.

Table 1 - AEC Purchases of U_3O_8 from Western Nuclear, Inc.-Split Rock, WY

Contract No.	Period (FY)	U_3O_8 (Lbs.)	Average Cost Per Lb. U_3O_8 ($)
AT(05-1)-709	1958[a]-1959	1,624,964	10.27
AT(05-1)-765	1960-1969[b]	13,310,605	7.85
Total	1958 - 1969	14,935,569	8.11[c]

a) First U_3O_8 delivered 8/57.
b) Last U_3O_8 delivered 6/69.
c) Average Fiscal Year costs ranged from $7.12 to $10.45.

Table 2 - Mill Production Data - Western Nuclear, Inc.-Split Rock, WY

	AEC Contracts[1]
Period of Operation	7/57-12/70
Uranium Ore	
Fed to Process (Tons)	4,004,282
U_3O_8 (%)	0.23
U_3O_8 (Lbs.)	18,541,002
Other Millfeed (U_3O_8 Lbs.)	
Heap Leach	88,597
Spook Concentrator Slurry	348,095
Total Millfeed (U_3O_8 Lbs.)	18,966,694[2]
Production	
U_3O_8 in Conc. (Lbs.)	17,720,644
U_3O_8 Recovered (%)	93
U_3O_8 Shipped to AEC (Lbs.)	14,924,249
U_3O_8 Shipped to Others (Lbs.)	2,719,618
U_3O_8 Ending Inventory (Lbs.)	75,040[3]

1/ Data for entire AEC contract period although WNI delivered no U_3O_8 to the AEC after 6/69.

2/ Total adjusted for in-plant inventory changes was 18,955,932 lbs.

3/ Short 1,737 lbs. reported stolen -- later recovered in Salt Lake City.

When Western Nuclear ceased deliveries of concentrate to the AEC at the end of June 1969, there were about 3.5 million tons of tailings impounded at the Slick Rock site, covering an area of approximately 83 acres to an average depth of about 25 feet. At the end of calendar year 1981 the tailings pile contained about 7.7 million tons of tailings and covered an estimated 167 acres to an average depth of approximately 28 feet. The tailings are attributable both to concentrate for sale to the AEC and to production for commercial sales.

Tailings stabilization has not yet been undertaken at the Split Rock site, although Western Nuclear has proposed a reclamation plan to the State. No tailings have been removed from the millsite.

As noted earlier, the Green Mountain ion exchange plant, which is located about 12 miles south of the Split Rock mill, is still operating. At the Rox mine ion exchange site, some 28 miles north-northeast of the mill, only a concrete pad remains, all buildings and equipment having been moved to the Split Rock facility.

Western Nuclear has estimated that between 200,000 and 400,000 tons of leached low grade uranium material remained at the Day-Loma heap leaching site, about 15 miles north of the Split Rock mill, and that 100,000 to 200,000 tons of leached low grade material remain at the Bull Rush heap leaching site, which is located some 20 miles north of the mill. As of the date of the Commingled Uranium Tailings Study, reclamation was reported to be under way at the Day-Loma site.

VANADIUM CORPORATION OF AMERICA
Monument Valley, Arizona

The Monument Valley upgrader was constructed by Vanadium Corporation of America (VCA) and was operated from mid-1955 until July, 1964. All of the feed for the upgrader was obtained from the nearby VCA Monument No. 2 mine and consisted of a carnotite-type mineralization in sandstone. Prior to 1955, the mine had a sizeable production of high grade and direct shipping grade ore which was produced by selective underground mining. Subsequently, the property was converted to an open pit and, except for a few truckloads per week of shipping grade ore, the mine production ranged in grade from 0.04 to 0.09% U_3O_8 and 0.4 to 0.8% V_2O_5. This mine production was too low grade to ship to the Durango mill. The upgrader enabled VCA to concentrate the mineralization in a product similar to direct shipping grade ore. The upgrader product (ore slimes) was shipped to the VCA Durango mill until it shut down in March 1963, and then to VCA's Shiprock mill. The U_3O_8 recovered from the upgrader product in the Durango and Shiprock mills was purchased by the AEC.

Prior to the shutdown of the upgrader, VCA determined that the upgrader sand tailings still contained sufficient values to warrant retreatment. Hence a second plant or concentrator, termed by VCA the "Upflow Batch Leach Plant", was constructed and commenced operation in October 1964. It operated for three years and was shut down in November 1967. The uranium and vanadium product from the concentrator was shipped to the Shiprock mill and U_3O_8 recovered therefrom was purchased by the AEC.

In 1966 VCA began heap leaching low grade ore at its Monument Valley operations. The uranium-vanadium precipitate from heap leaching was also processed in the Shiprock mill and the AEC purchased U_3O_8 attributable to that production.

The VCA upgrader, concentrator, and heap leach operation were located on a 90-acre site on the Navajo Indian Reservation in Cane Valley about 20 miles south and east of the Mexican Hat, Utah mill. Access to the facilities was by an improved gravel road from the Mexican Hat millsite or by means of an unimproved gravel road running almost due west from Shiprock, New Mexico. The site is in Apache County, Arizona, about 5 miles south of the Utah-Arizona border. The country surrounding the site is desertlike with hills, steep ridges, and mesas. Vegetation is sparse and few Indians reside in the area.

During the period of operation of the upgrader, from mid-1955 until June 1964, an estimated 1,100,000 tons of low grade mine production were fed to process. Feed grade ranged from 0.04 to 0.09% U_3O_8 and 0.4 to 0.8% V_2O_5. The upgrader operated at a feed rate of about 500 tons per day (tpd), although it is reported that at times the total feed rate exceeded 700 tpd. The product, a slime concentrate, contained approximately 10 percent moisture, and assayed 0.25 to 0.30% U_3O_8 and 1.5 to 3.0% V_2O_5, depending on the millfeed grade. Production was 40 to 50 tons per day and an estimated total of 100,000 tons for the life of the upgrader. Recovery was estimated at about 60 percent of both uranium and vanadium. Truck haulage distance to the Durango mill was 170 to 185 miles depending on the route taken. The Shiprock mill was somewhat closer.

The upgrader consisted of two nearly identical parallel circuits, each operating at a feed rate of about 250 tpd. The flowsheet for the operation was very simple. The run of mine ore was crushed to about one inch and then ground in rod mills to about 10-mesh. The ground pulp was classified in spiral classifiers and the slime fraction was thickened and the sands were pumped to the tailings area. The thickener underflow was further classified with cyclones to reject additional barren sand which was discarded to tailings. The slimes from cyclone treatment were filtered on disc filters and the wet cake was dried in two steps in oil-fired rotary driers. The slime concentrate represented 10 percent of the original feed weight. No chemicals, other than flocculants, were used in the upgrader operation.

The concentrator retreated the accumulated sand tailings from the upgrader operation. It operated from October 1964 until November 1967, and processed approximately one million tons of sand tailings at an average feed rate of about 1,000 tpd. The plant consisted of large lined steel tanks in which sand tailings were placed for leaching by an upward flow of a sulfuric acid solution. When essentially all the values has been extracted, the tank was emptied to tailings. When solutions had been recycled sufficiently to reach the desired uranium and vanadium contents, ammonia was added to neutralize the acid and precipitate the uranium and vanadium. The precipitate was filtered, partially dried, and trucked to the Shiprock mill. No data are available on the tonnage of precipitate nor the U_3O_8 and V_2O_5 contents. One could assume that about 200,000 lbs. U_3O_8 and two million lbs. V_2O_5 were recovered, if the sand tailings feed contained an average of 0.02% U_3O_8 and 0.2% V_2O_5 and that 50 percent of the values were extracted and recovered. The quantity (tonnage) of sand tailings from the concentrator would have been essentially equal to the feed tonnage because so little weight of uranium and vanadium was removed.

The heap leaching started on an experimental basis in 1966 and proved attractive for treating low grade mine dumps. The material was crushed to one inch and placed on polyethylene sheeting with orangeburg pipes for solution collection. Sulfuric acid solution was percolated through the heaps until a concentration of about 1.5 g. U_3O_8 per liter and 7.0 g. V_2O_5 per liter was obtained, then ammonia was added to precipitate the values. The precipitate was handled in the same manner as that from the concentrator. Heap leaching continued intermittently (winter shut downs were sometimes required) until late 1967 when all activities ceased. The total quantity of low grade material that was heap leached is not known but has been estimated to be as much as 100,000 tons (Report DOE/EP-0011).

The Monument Valley operations generated an estimated 1,100,000 tons of sand tailings and heap leach residues. The tailings are in two piles about 500 feet apart. One pile covers an area of about 10 acres and is located east of the concentrator or upgrader. It is estimated to contain 165,000 tons with an average depth of 2 to 3 feet. The second pile, covering 20 acres, is 500 feet to the east of the other pile, and is cone shaped and approximately 55 feet high. This pile is estimated to contain 935,000 tons. The heap leach residues are thought to be contained in the smaller pile.

The old plant buildings have been removed. Foundations, rubble, and the tailings remain. The site is neither fenced nor posted, and the tailings have not been stabilized. There are a few Indian dwellings in the vicinity, three 1,100 feet from the eastern edge of the site.

The upgrader, concentrator, and heap leaching facilities were constructed and operated by VCA and its successor, Foote Mineral Company, after August 31, 1967. The site was leased from the Navajo Nation. After the plants were closed and dismantled, control of the site and the tailings reverted to the Navajo Nation in 1968, when the VCA lease expired.

The site and tailings are described in detail in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has been assigned a "low" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

Radiological surveys in the area of the site indicate that the potential health impact of the tailings is minimal, considering the low population density and the low grade of material processed. Aerial and ground radiological surveys by the DOE to define the extent of tailings transported offsite are scheduled for 1983.

NORTH CONTINENT MINES, INC.
Slick Rock, Colorado

The North Continent mill at Slick Rock, Colorado, was constructed in 1931 by Shattuck Chemical Company for the extraction of vanadium and radium salts. It was acquired by North Continent Mines, Inc. in 1939. In February of 1945 it was purchased by Union Mines Development Corporation, which had been established by the U.S. Government to acquire uranium and vanadium for the Manhattan Project during World War II. Union Mines deeded the property to the U.S. Government in February of 1949, together with numerous uranium mining properties which had been acquired by Union Mines in San Miguel County, Colorado. In November of 1957, the Government deeded the 160 acre plot, which included the North Continent townsite, millsite, and tailings area, to Union Carbide Corporation, retaining the mineral rights.

The 160-acre North Continent site is located about 2 miles northwest of Slick Rock, Colorado, on the southwest side of the Dolores River, approximately 10 miles east of the Colorado-Utah border. The plant operated from 1931 until 1943, when it was shut down by North Continent Mines, Inc. During the period of its operation the mill treated an estimated 37,000 tons of ore averaging 0.28% U_3O_8 and about 3.00% V_2O_5. The recovery percentages for uranium and vanadium are not available, nor is the quantity of U_3O_8 which was sold to the Manhattan Engineer District.

In the original process, the ground ore was mixed with concentrated sulfuric acid and water and the mix allowed to cure for about 24 hours in order to render soluble both the uranium and vanadium values. The cured mass was broken up, pulped with water, and then classified by means of a countercurrent classification-wash step. The insoluble radium-bearing slimes and soluble vanadium and uranium values were removed in the overflow and the sand rake product sent to waste. The radium-bearing slimes were recovered and washed in a filter press, then dried and shipped to Shattuck Chemical Company in Denver for final treatment. The acid leach liquor was evaporated in lead-lined vessels and steam-jacketed kettles to near dryness. The solid residue was then roasted in a reverberatory furnace at 1,200°F. for conversion of the vanadium sulfate to iron vanadate. The soluble uranium and aluminum salts in the calcines were dissolved in water and the insoluble iron vanadate separated and washed in a filter press. The iron vanadate was dried and later converted to ferro-vanadium. A waste aluminum hydroxides product was then clarified and a low grade uranium concentrate was precipitated with caustic soda. This product was converted to uranyl acetate or uranyl nitrate by dissolving in the corresponding acid and crystallizing the uranium salts.

A modification of the acid cure process used at Slick Rock included a vanadic acid precipitation step for vanadium recovery. In this step the vanadic acid was precipitated by proper pH adjustment of the boiling solution after the addition of an oxidizing agent. The vanadic acid was fused into the commercial vanadium product. The uranium-bearing filtrate was partially neutralized with soda ash to produce a ferric sulfate, which was filtered off and discarded. The filtrate was neutralized with caustic soda and a low grade uranium precipitated. This product was further refined by redigesting in sodium carbonate solution and evaporating to crystallize a sodium uranyl carbonate salt.

In 1941 a combination of salt roast, water leach, and acid leach process was adopted. In these steps part of the vanadium was extracted in the water leach circuit, while additional vanadium and the uranium were extracted in the acid leach circuit. The two liquors obtained were clarified and combined to produce a vanadic acid salt after oxidation and hydrolysis. The "red cake" was fused for shipment. The uranium-bearing filtrate was treated with soda ash to precipitate a waste alumina cake, and the uranium was recovered by precipitation from the filtrate by the addition of caustic soda.

The plant began operation with a capacity of 10 to 15 tons of ore per day (tpd) which increased in 1942 to 30 tpd with the addition of a rotary kiln roaster.

The North Continent Slick Rock operation generated an estimated 37,000 tons of tailings, of which 300 to 400 tons were removed for reprocessing at Union Carbide's Slick Rock concentrator and its Uravan, Colorado, mill. The remaining tailings cover an area of 6 acres. The base of the pile is about 8 feet above the Dolores River and the top is about 50 feet above the river. The distance from the tailings to the river ranges from 15 to 75 feet.

When the mill facility was dismantled, the bricks from the roaster were buried in the tailings pile. The pile has been contoured, covered with 6 inches of soil, seeded, and fertilized, in accordance with regulations of the State of Colorado in effect in 1971, when the stabilization work was done. All of the housing, mill equipment, and associated buildings have been removed from the site. The property, which is still owned by Union Carbide, is fenced and posted. Other than as described, no tailings are known to have been removed from the site.

The site and tailings are described in detail in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has been assigned a "low" priority under the Uranium Mill Tailings Radiation Control Act of 1978.

Gamma radiation surveys in the Slick Rock area have indicated anomalous radioactivity at a few offsite locations. The DOE plans additional surveys to determine whether or not any vicinity properties will require remedial action.

UNION CARBIDE CORPORATION
Slick Rock, Colorado

The Slick Rock concentrator was constructed by Union Carbide Corporation and was operated from September of 1957 until December of 1961 in conjunction with Union Carbide's operation of its Rifle, Colorado, milling facilities for the production of uranium concentrate for sale to the AEC.

The Slick Rock concentrator was located on a site of approximately 360 acres, bordered on the north and east by the Dolores River, about 9 miles east of the Colorado-Utah border and some 3 miles northwest of the Slick Rock, Colorado, post-office. Slick Rock is approximately 135 road miles south of Grand Junction, Colorado. During the period of its operation the Slick Rock concentrator processed ore at an average rate of about 430 tons per day (tpd), treating 591,244 tons of ore averaging 0.24% U_3O_8, and producing concentrated ore products containing 2,691,035 pounds of U_3O_8. The concentrated products were trucked to Union Carbide's Rifle mill, about 60 miles east of Grand Junction, for final processing. Recovery of U_3O_8 at the Slick Rock operation averaged 93 percent.

Ore fed to process at the Slick Rock concentrator averaged 1.35% V_2O_5, but data on vanadium recovery are not available.

In the Slick Rock process, dry-grinding and air-sizing were used to produce a minus 14-mesh product and recover a large portion of the fine fraction, which constituted the first concentrate. The coarse ore fraction was combined with recirculated acid solution, and a sand-slime separation then was made on the slurry. The sand product was further acid-leached, washed, and discharged to tailings. The slimes were dewatered and dried as a second concentrate. A third product resulted from ammonia neutralization of part of the pregnant solution from leaching of the sands. This precipitate was combined with the wet slimes and dried as a single product. About 60 percent of the uranium was contained in the initial dry-fine product and an additional 30 to 35 percent was contained in the combined slimes and precipitate.

The Slick Rock concentrator operation generated an estimated 350,000 tons of tailings, which cover an area of about 19 acres. The base of the tailings pile is about 10 feet above the Dolores River and the top of the pile is some 60 feet above the river. Because of a horseshoe bend of the river, the distance of the pile to the river varies from 35 to 300 feet.

Stabilization has consisted of covering the pile with approximately 6 inches of soil and seeding it to provide vegetation; construction of a small earth dike between the pile and the river, and grading around the pile to isolate it from surrounding water runoff. The tailings are fenced and radiation warning signs are displayed.

Union Carbide Corporation owns all of the original 360 acres site except for a five-acre plot that was sold to Rocky Mountain Gas Company, which has constructed a gas sweetener plant on the plot. The concentrator buildings have been removed from the site, although some concrete foundations remain.

The site and tailings are described in detail in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has been assigned a "low" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

Gamma radiation surveys in the Slick Rock area have indicated anomalous radioactivity at a few offsite locations. The DOE plans additional surveys to determine whether or not any vicinity properties will require remedial action.

UNION CARBIDE CORPORATION[1/]
Belfield, North Dakota

In conjunction with the operation of its Rifle, Colorado milling operation, Union Carbide Corporation constructed a rotary kiln near Belfield, North Dakota, and operated the facility from July of 1965 to November of 1967. The rotary kiln burned uraniferous lignite coal from the surrounding area and produced a lignite ash product that was shipped to the Rifle facility for recovery of the contained uranium.

The lignite burning facility, with a nominal capacity of 125 tons per day, was located approximately a mile southeast of the town of Belfield, directly north of the Burlington Northern railroad track and about 700 feet east of U.S. Highway 85. During the period of its operation the facility processed uraniferous lignite coal at an average rate of about 60 tons per day, treating a total of 47,614 tons of material averaging 0.37% U_3O_8, and producing lignite ash containing 338,393 pounds of U_3O_8. Uranium recovery in the plant averaged 93 percent. All of the ash product was shipped to the Rifle mill, about 60 miles east of Grand Junction, Colorado.

The following steps were involved in the Belfield burning process. Truckloads of lignite were weighed and sampled, and the ore was crushed to minus 2-inch size by a double rotor impact crusher and fed into the 8 by 125-foot rotary kiln. Calcining temperature varied from 1,300° to 1,600°F., depending on the material being burned. The temperature was kept to 100 degrees below the fusion point of the ore.

The first 50 feet of the feed end of the natural gas-fired kiln was lined with a 6-inch thickness of castable refractor lining, since the temperature there reached only about 800°F. The remainder was lined with 6-inch firebrick. The kiln had eight valves or outlets along the side, which could be opened as required to cool off any hot spots detected by the units four thermocouples. The hot ash passed through a 5 by 50-foot rotary cooler, then was crushed to minus 1/8-inch and loaded into railroad cars for shipment to the Rifle plant.

Kiln dust was collected by a wet scrubber, sent to a thickening tank, and returned to join kiln discharge at the rotary cooler. Oversize dust particles were separated out by a cyclone, and joined the ash discharged from the cooler. During cold weather, this coarse fraction of hot dust was returned to the front end of the process and mixed with the kiln feed to keep the raw ore from freezing.

Union Carbide Corporation had leased the 8 acres site from the Burlington Northern Railway Company, which still owns the land. After Union Carbide closed down the Belfield operation, it cleaned and decontaminated the plant equipment, and yard to then—current AEC requirements. Structures still remaining at the site are owned by a construction company, which has leased a portion of the site from the railroad company. While no stabilization, as such, has been undertaken, portions of the site have been covered with gravel to provide a parking area, and vegetation is generally well established in the remaining open areas of the site.

1/ Experimental lignite burning by GeoResources and Susquehanna-Western, Inc. is also discussed at the end of this report.

The Belfield burning process generated an ash residue that contaminated the surface of the site and an estimated 21 acres surrounding the site. The contaminated area, like the site proper, parallels the Burlington Northern railroad. No clearly delineated pond or pile of tailings or residues exists, but contaminated material on and off-site (windblown) is estimated to total about 71,500 tons, or about 56,600 cubic yards. Since the ash from the process was the valued and only product it has been assumed that there has been no intentional removal of contaminated material for use off-site.

The site is described in detail in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). It has been assigned a "low" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

The extent of on-site and windblown contamination was assessed in 1980 by a DOE contractor. The assessment did not include a search for or evaluation of off-site vicinity locations that might require remedial action. Further aerial and ground radiological surveys were planned by the DOE to characterize the radiological status of the site proper and to define the extent of transport of residual radioactive material from the site into the surrounding areas.

Another lignite mining company, GeoResources, had a small experimental rotary lignite burner near Belfield, about one-quarter mile from the Union Carbide operation. It is reported that GeoResources was discouraged with its experimental burning and late in 1964 planned to dismantle the burner. Similarly, Susquehanna-Western, Inc. experimented with a small rotary kiln, 30 feet long and 6 feet in diameter, to burn lignite in the Slim Buttes area of South Dakota but the operation was unsuccessful. The burner was later placed in the Pickpocket pit in North Cave Hills, South Dakota, but no information is available on its use, if any, at that location. Late in 1964, plans had been made to move the burner to Susquehanna's mill at Edgemont, South Dakota.

KERMAC NUCLEAR FUELS CORPORATION
Bowman, North Dakota

The Bowman, North Dakota, lignite burning facility was constructed by Kermac Nuclear Fuels Corporation, a subsidiary of Kerr-McGee Oil Industries, Inc., and was operated in conjunction with Kermac's operation of its Ambrosia Lake, New Mexico, milling facilities for the production of uranium concentrate for sale to the AEC.

Kermac had the largest lignite burning plant in the area. It was reported to have cost about $500,000 when constructed late in 1963 and in early 1964 and to have a design capacity of 225 tons of lignite ore per day (tpd).

The Bowman rotary kiln operation was located on an 11.7-acre site in an agricultural area approximately 7 miles west of Bowman, North Dakota, some 25 miles north of the border between South and North Dakota and about 35 miles east of the Montana state line. The site is south of and adjacent to a siding of the Chicago, Milwaukee, St. Paul and Pacific Railroad (the Milwaukee Road). During the period of its operation, from March 1964 until February 1967, the plant processed uraniferous lignite ore at an average rate of about 80 to 90 tpd. The raw lignite was upgraded about two times in the burning operation. A total of 80,374 tons of raw lignite containing 686,000 pounds of U_3O_8 was burned. The ash, containing 607,000 pounds of U_3O_8 and 290,000 pounds of molybdenum, was shipped by rail to Kermac's Ambrosia Lake mill for processing. The resulting uranium concentrate was sold to the AEC and the molybdenum was sold in the commercial market.

At the ashing site the raw, wet lignite was transferred from stockpiles to receiving hoppers by a front-end loader. The raw feed was crushed and fed to three rotating 7-foot diameter by 120-foot long kilns, each of which was fired by a 6-inch diameter gas burner in the discharge end. The raw feed was dried in the first 18-foot long section of the kiln. Combustion of the dry lignite in the remaining 102 feet of the rotating kiln was controlled by varying the air flow, exhaust flow, pressure, and temperature. The burned product discharged from a shaker conveyor onto a vibrating screen. The oversized material was further crushed to a minus 6-mesh, then fed to an elevator which raised the product for loading into railway cars for shipment to the Ambrosia Lake mill, where it was slurried and fed into the regular leaching circuit at a rate of 60 to 100 tpd.

The buildings and kilns used in the ashing process have been removed from the site, which is owned by a local farmer. The site is covered with native weeds and grasses. No tailings, ash pond or pile is present at the site, because the ash from the kiln was collected and shippped to Ambrosia Lake for further processing. However, gamma logs of drill holes at the site indicate that most of the soil on the site has residual contamination and in some places it extends to depths of about 3 feet. The total area of contamination, including the windblown area, covers about 36.5 acres. The total volume of contaminated materials have been estimated to be about 76,800 cubic yards, weighing about 97,000 tons at field conditions. None of the contaminated material is known to have been removed from the site.

The burning site is described in detail in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has been assigned a "low" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

UNION CARBIDE CORPORATION
Green River, Utah

The Green River concentrator was constructed by Union Carbide and was operated from March of 1958 to January of 1961 in conjunction with Union Carbide's operation of its Rifle, Colorado, milling facilities for the production of uranium concentrates for sale to the AEC.

The Green River concentrator was located on an 80-acre site in Grand County, Utah, about a mile southeast of the town of Green River and approximately a half mile east of the river from which the town takes its name. During the period of its operation the Green River concentrator processed ore, mined from the Temple Mountain, Utah, area, at an average rate of about 200 tons per day. It treated a total of 183,386 tons of ore averaging 0.29% U_3O_8 and produced concentrated ore products containing 831,082 pounds of U_3O_8. Recovery of U_3O_8 during the period averaged 87 percent. The concentrator also recovered vanadium, which averaged about 1.00% in the millfeed, but data on the percentage of vanadium recovery are not available. All of the concentrated product produced by the concentrator was shipped to Union Carbide's Rifle mill, about 60 miles east of Grand Junction, Colorado, for final processing.

The concentrator used a combination of flotation, sand-slime separation, and acid leaching of the carbonaceous ores that constituted its millfeed. The ore was crushed, then ground to minus 35-mesh in a rodmill. A coarse uranium-bearing carbonaceous fraction was removed by screening. Next, the screen undersize was subjected to flotation to recover the remainder of the carbonaceous material. This process resulted in a combined carbon concentrate. The primary slimes were removed from the flotation tailings in classifiers and cyclones, and the sands were leached with sulfuric acid. After being washed in classifiers, the leached sands were discarded and the resulting acid-slime slurry was combined with the primary slimes. Ammonia was then added to precipitate the uranium, and the combined precipitate and slimes were thickened, filtered, and dried for shipment by rail to Rifle, along with the carbon concentrate.

The Green River concentrator operation generated an estimated 137,000 tons of tailings. Subsequent to the plant shutdown, however, a flash flood washed away about 14,000 tons of tailings, leaving an estimated 123,000 tons, which covers an area of about 9 acres to an average depth of 7 feet.

The tailings have been stabilized with 6 inches of earth cover. Surface water drains into a pond on the northwest corner of the pile, and some riprapping and diking have been placed around the north and east edges of the pile to protect it from normal runoff waters of a wash which parallels the north edge of the site. The tailings are fenced with barbed wire.

Union Carbide Corporation still owns the site and the mill buildings, which remain on the site.

The concentrator site and tailings are described in detail in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has been assigned a "low" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

Mobile and follow-up ground gamma radiation surveys have indicated possible use of tailings off-site in the Green River vicinity. Further surveys have been scheduled by the DOE.

COG MINERALS CORPORATION
White Canyon Mining District, Utah

The upgrader was constructed and operated by COG Minerals Corporation, a subsidiary of Colorado Oil and Gas Corporation. COG Minerals operated three mines, namely, the Spook, Bullseye, and Coleman in the White Canyon District of southeastern Utah. The ores of the White Canyon District were destinctive in that there were sulfide copper minerals, and sometimes substantial quantities of pyrite, associated with the uranium minerals. Ores from the district were usually sold to the Texas-Zinc Minerals Corporation mill at Mexican Hat, some 70 miles away. The long haulage, and ore grade requirements of the mill, made it necessary for the miners to ship only the very best grade of ore for profitable operation. These conditions prompted COG to install facilities to upgrade material that otherwise would have been a waste product.

The upgrader was located in a remote desert area approximately 60 miles west of Blanding, Utah, and was accessible by a dirt and gravel road. The upgrader was constructed on the hillside adjacent to the Fry Spring Area, from which water for plant operation was obtained. Extensive metallurgical test work was conducted by COG to develop the necessary upgrader flowsheet and design. The initial design of the upgrader was for a 75 tons of ore per day (tpd) pilot plant, but within seven months of operation the plant had been expanded to a 200 tpd capacity. The upgrader started operation early in 1957 and operated for about three years. It was shut down in early 1960.

During its operating life the upgrader processed approximately 50,000 tons of ore estimated to contain between 0.10 and 0.15% U_3O_8. All production, consisting of three products (a gravity concentrate, a flotation concentrate, and slimes), was shipped to the Texas-Zinc mill at Mexican Hat. The gravity concentrate, representing 1.5% by weight of the ore, contained 4.20% U_3O_8 and 17.4% Cu. The flotation concentrate amounting to 1.0% by weight of the ore, assayed 0.30% U_3O_8 and 22.0% Cu. The slimes constituted 19.8% of the ore weight and contained roughly twice the U_3O_8 grade of the ore fed to process, or 0.20% to 0.30% U_3O_8. Texas-Zinc paid a premium for the U_3O_8 in the concentrates and the regular ore prices (Circular 5, Rev.) for the U_3O_8 in the slimes. The AEC purchased the U_3O_8 attributable to the COG upgrader production that was recovered by Texas-Zinc.

The upgrading process used by COG consisted of conventional crushing and grinding to minus 6-mesh, at a rate of 8 tons per hour, in a rod mill. The mill discharge was sampled and then fed to a jig where the high grade gravity concentrate was recovered. The jig tailing was pumped to Humphrey spirals with the spiral concentrate being cleaned on a Wilfley table, and the spiral tailing passing to flotation where additional copper sulfide minerals were recovered. The flotation circuit tailings then were classified and cycloned to separate the sands and slimes. The sand tailings were pumped to waste and the slimes were thickened and pond dried during early operations. In the latter stages of operation, a filter was installed for dewatering the slimes. A U.S. patent (No. 2,968,524 issued January 17, 1961) was granted for the upgrading process invented by COG Minerals.

It is estimated that about 40,000 tons of sand tailings analyzing about 0.02% U_3O_8 had been impounded when the upgrader shut down. When operations ceased, COG sold the plant to Western Nuclear, Inc. Western Nuclear moved the buildings and most of the milling equipment to Wyoming for use in constructing its Spook concentrator. That equipment not useable at the Spook facility was consigned to a Salt Lake City used equipment dealer. Western Nuclear removed everything but the fine ore bin.

Several years later another company acquired the site and water rights and began a copper leaching operation using ore from the 3-Aces Mine. The fine ore bin was lined and used as a leach tank. The dissolved copper was precipitated by use of hydrogen sulfide. No data are available on the amount of ore processed or the duration of the operation.

Apparently the sand tailings from the COG operation have been covered with residues from copper leaching. The authors have no knowledge of radiological surveys of the site.

SHAWANO DEVELOPMENT CORPORATION
Baggs, Wyoming

The Baggs, Wyoming, facilities were constructed by the Shawano Development Corporation and were operated for a short period of time in the mid-1950s. A wet-process upgrader was constructed in 1956 to treat low grade material from Shawano's nearby open pit mine. The upgrader consisted of a trommel to disaggregate the ore and a spiral classifier to effect a sand-slime separation. Uranium minerals were expected to report in the slime fraction. Inefficient classification, difficulty in dewatering the slimes, and losses of soluble uranium caused failure of the process.

Subsequently, the upgrader plant was converted to a pilot plant, in which an acid leach process was used, uranium being recovered by ion exchange and caustic precipitation. Later the pilot plant was adapted to a carbonate-bicarbonate leach process and about 1,000 pounds of sodium diuranate concentrate was produced. This concentrate was purchased by the AEC under its "small lot concentrate purchase program."

Shawano approached the AEC about entering into a contract to construct a full-scale mill in the area but lack of an adequate ore supply and financial difficulties prevented consummation of a contract.

The Baggs plants were located on an 11-acre triangular site near the Poison Butte Mine in Section 4, T. 12 N., R. 92 W., Carbon County, Wyoming. The site is about 6 miles west-southwest of Baggs, Wyoming, and about 2 miles north of the Colorado border. The site is generally flat and is surrounded by small bluffs and gently rolling hills covered with range grass.

No operating data are available for the Shawano upgrader and pilot plants; however, the mine is reported to have had large tonnages of low grade material (0.04 to 0.09% U_3O_8) available for upgrading. A DOE contractor visited the site in October 1979 and determined that the tailings covered an area of 0.4 acres and were piled to a depth of about 20 feet. These data indicate that about 15,000 tons of tailings remain on the site. Ore and overburden piles are also located in the vicinity of the site.

Although Shawano was reported to be the initial owner of the site, Shawano's ownership is now in question because the site is on public land administered by the Bureau of Land Management, Department of Interior.

The upgrader and pilot plant site and tailings are briefly described in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has been assigned a "low" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

WYOMING MINING AND MILLING COMPANY
Converse County, Wyoming

The Spook concentrator was constructed in late 1961 and early 1962 by Wyoming Mining and Milling Company, which was owned by the same persons who owned its parent company, Western Nuclear, Inc.

The plant was operated from April of 1962 until June of 1965 in conjunction with Western Nuclear's operation of its Split Rock, Wyoming, mill for the production of uranium concentrates for sale to the AEC.

The Spook concentrator was located on a site adjacent to an open-pit mine in the Powder River Basin, Converse County, Wyoming, approximately 40 miles northeast of Casper and about 165 miles northeast of the Split Rock mill. During the period of its operation it processed ore at an average rate of about 200 tons per day, treating approximately 187,000 tons of ore averaging 0.12% U_3O_8. The resulting slurry, containing a total of 348,095 pounds of U_3O_8, was trucked to the Split Rock mill for final processing and packaging.

The process and equipment used at the Spook site were unique. Following crushing to about 0.75 inch, the sandstone ore was mixed with water and sulfuric acid, pelletized, and allowed to cure for about 14 hours. The uranium was leached in false-bottom rectangular concrete tanks, the acid solution being recycled until the desired uranium concentration was attained. The pregnant solution then passed through tanks containing ion exchange resins where the uranium was removed and the solution recycled to leach. Uranium was eluted from the resin and precipitated with ammonia to form the slurry that was shipped to the Split Rock mill.

The acid-leached residues were removed from the tanks by a front-end loader and were dumped into the open-pit mine adjacent to the concentrator.

The Spook site consists of the large open pit from which the ore for the operation was taken, the former concentrator site, piles of overburden and mine waste material, and the area of about 5 acres, on the banks of the pit, where the tailings are deposited. The concentrator buildings have been removed, but some concrete foundations, machine parts, timbers, overhead electric equipment, and sheds remained as of April 1981. A barbed wire fence surrounds the site, which covers a total area of about 15 acres. No stabilization has been undertaken, although the entire area is covered by about a 10 percent growth of weeds and native grasses.

The site and tailings are described in detail in the report, Background Report for the Uranium Mill Tailings Sites Remedial Action Program, April 1981 (DOE/EP-0011). The site has been assigned a "low" priority for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978.

The remoteness of the site suggests that there are no offsite locations where tailings may have been used for construction purposes.

APPENDIX B: STATISTICAL DATA

Table B-1 - AEC Ore Buying Stations - Summary of Ore Receipts B-3

Table B-2 - Vanadium Purchases Under AEC Contracts B-5

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Table B-1 - AEC Ore Buying Stations - Summary of Ore Receipts*

Location and Years	Ore Dry Tons	U_3O_8 %	U_3O_8 Pounds	V_2O_5 %	V_2O_5 Pounds
ARIZONA					
Globe (FY 1956 thru 1958)	23,885	0.20	97,421	0.02	10,488
Tuba City (FY 1956 thru 1957)[1/]	40,782	0.22	178,610	0.05	42,241
NEW MEXICO					
Bluewater (FY 1952 thru 1958)[1/]	320,726	0.32	2,035,027	0.18	1,123,187
Grants (FY 1957 thru 1959)	95,228	0.28	524,227	0.11	156,063
Shiprock (FY 1952 thru 1958)	129,638	0.28	729,918	1.08	2,810,224
SOUTH DAKOTA					
Edgemont (FY 1953 thru 1958)	105,250	0.24	497,802	0.30	627,271
TEXAS					
Falls City (FY 1960 thru 1963)[1/]	100,000	0.24	408,234	--	--
UTAH					
Marysvale (FY 1950 thru 1958)	130,674	0.24	622,027	0.02	40,572
Mexican Hat (FY 1959 thru 1960)[1/]	4,297	0.21	17,765	--	--
Moab (FY 1954 thru 1960)	687,685	0.33	4,579,553	0.49	6,542,036
Moab (FY 1958 thru 1964)[1/]	154,828	0.54	1,677,039	--	--
Monticello (FY 1949 thru 1962)	1,067,864[2/]	0.31	6,575,176	0.51	10,289,086
Salt Lake City (FY 1953 thru 1958)[1/]	34,988	0.33	232,922	--	--
White Canyon (FY 1955 thru 1958)	179,635	0.25	915,696	0.01	26,037
WYOMING					
Crooks Gap (FY 1958)[1/]	68,271	0.20	268,466	0.02	32,225
Riverton (FY 1955 thru 1958)	152,701	0.23	716,246	0.11	322,248
Shirley Basin (FY 1961 thru 1965)[1/]	72,215	0.35	507,175	--	--
OTHER PROCUREMENT (FY 1953 thru 1959)	142	0.44	1,249		
Totals	3,368,809	0.31	20,584,553	0.37[3/]	22,021,678

1/ Mill contractor was ore buying agent for the AEC or leased sampling plant to AEC for operation.

2/ 907,917 tons were fed to process in the AEC's Monticello mill. (See Appendix A, Monticello report).

3/ Average V_2O_5 grade only for the 3,002,339 tons of ore that were analyzed for V_2O_5.

* Not included in these ore receipts was the 22.25 dry tons of high grade ore containing 22.92% U_3O_8 that was delivered to the AEC at Grand Junction, CO, on April 9, 1958, by Lisbon Uranium Corp. to qualify for the first and only $10,000 bonus paid under D.U.P., Circular No. 2, which expired on April 11, 1958. The ore came from Lisbon's properties in the Big Indian Wash area near Moab, Utah, and for the one truckload Lisbon received $61,016.72 (including the bonus) or $5.98/lb. U_3O_8. The ore was crushed and sampled in the AEC's pilot plant, operated by National Lead Company, Inc., and was shipped directly to the AEC's Feed Materials Plant at Fernald, Ohio, for processing.

Table B-2 - Vanadium Purchases Under AEC Contracts

Location and Contractor	Period of Deliveries	Total Pounds V_2O_5	Percent of AEC Purchases
COLORADO			
Durango, Vanadium Corp. of Am.	FY 1950-1959	5,791,738	20
Naturita, Vanadium Corp. of Am.	FY 1949-1955	3,143,513	11
Grand Junction, Climax Uranium Co.	FY 1957-1959	3,276,224	12
Rifle, Union Carbide Corp.	FY 1949-1955	4,323,640	15
Uravan, Union Carbide Corp.	FY 1950-1959	9,738,791	34
UTAH			
Monticello, The Galigher Co.[1/]	FY 1951-1956	2,341,869	8
Total	FY 1949-1969	28,615,775[2/]	100

1/ Production from AEC-owned mill so contractor was credited at $0.98475 per pound V_2O_5 delivered, the same as the price paid other producers.

2/ Of this total 25,879,559 pounds were transferred to the General Services Administration. The remainder was sold by the AEC on a competitive bid basis in 1960 and 1961 to V.C.A., Union Carbide and Others.

Table B-3 - AEC Purchases of U_3O_8 in Concentrates from Uranium Mills by Fiscal Year[1/]

Fiscal Year	Pounds U_3O_8	Average Cost ($/Lb.)	Total Cost ($)
1948	231,903	7.14	1,655,880
1949	230,455	8.53	1,966,768
1950	646,272	9.11	5,887,265
1951	1,278,215	10.10	12,906,590
1952	1,647,524	11.28	18,578,682
1953	1,935,302	12.35	23,903,517
1954	2,870,462	12.27	35,233,082
1955	4,250,135	12.25	52,082,723
1956	8,357,600	11.51	96,170,287
1957	15,009,218	10.49	157,374,989
1958	20,155,894	9.45	190,480,031
1959	30,057,600	9.12	274,111,031
1960	32,787,602	8.75	286,980,167
1961	35,291,150	8.50	299,837,516
1962	34,488,702	8.15	280,980,208
1963	31,504,165	7.82	246,247,270
1964	25,213,735	8.00	201,743,432
1965	22,480,676	8.00	179,835,320
1966	20,356,742	8.00	162,827,506
1967	17,804,760	8.00	142,434,093
1968	15,874,830	8.00	126,992,952
1969	14,248,975	6.99	99,578,679
1970	8,019,018	5.74	46,045,677
1971	2,590,474	5.54	14,341,010
Totals	347,331,409	8.52	$2,958,194,675[2/]

1/ This table excludes U_3O_8 purchases from Porter Bros. at Lowman, Idaho. The AEC bought 365,231 lbs. U_3O_8 from Porter Bros. at a cost of $5,482,433 ($15.01/lb.)

2/ Total other AEC purchases from phosphate and other miscellaneous domestic sources made during the period FY 1953-1962, including Porter Bros., amounted to 1,487,029 lbs. U_3O_8 at a total cost of $21,195,574 ($14.25/lb.)

Table B-4 - Uranium Mill Operations Under AEC Contracts and Other Uranium Processing Plants

Location & Initial Contractor	Operating Period	Ore Processed			Other Feed	Total Millfeed	Production	Recovery	U_3O_8 Purchased by AEC	
		Tons	% U_3O_8	U_3O_8 (Lbs.)	U_3O_8 (Lbs.)	U_3O_8 (Lbs.)	U_3O_8 (Lbs.)	%	Lbs.	Average Cost ($/Lb.)
ARIZONA										
Tuba City, Rare Metals Corp.	6/56-9/66	796,489	0.33	5,233,029	--	5,233,029	4,696,402	90	4,698,361	9.65
COLORADO										
Canon City, Cotter Corp.	7/58- 2/65	319,384	0.54	3,419,198	--	3,419,198	3,196,597	93	3,142,988	8.23
Durango, Vanadium Corp. of Am.	3/49- 3/63	1,605,234	0.29	9,378,083	458,909	9,836,992	7,851,425	80	7,851,425	9.77
Grand Junction, Climax Uran. Co.	5/51-12/66	1,822,696	0.28	10,205,622	--	10,205,622	9,454,705	93	9,425,891	9.35
Gunnison, Gunnison Mining Co.	1/58- 4/62	540,423	0.15	1,644,011	--	1,644,011	1,450,976	88	1,449,680	9.55
Maybell, Trace Elements Corp.	11/57-10/64	1,764,753	0.13	4,565,291	--	4,565,291	4,033,744	88	4,033,744	8.86
Naturita, Vanadium Corp. of Am.	5/47- 2/58	594,568	0.30	3,539,141	--	3,539,141	2,719,690	77	2,775,842	10.45
Rifle (Old), Union Carbide Corp.	10/47- 1/58	693,495	0.35	4,896,100	146,449	5,042,549	4,274,976	85	4,274,976	11.31
Rifle (New), Union Carbide Corp.	1/58-12/70	1,802,019	0.23	8,414,731	4,508,497	12,923,228	11,649,298	90	11,704,588	8.73
Uravan, Union Carbide Corp.	12/49-12/70	5,728,778	0.23	26,804,004	234,318	27,038,322	24,619,976	91	23,857,710	9.34
IDAHO										
Lowman, Porter Bros. Corp.[1]	1956-1960	200,000(e)	0.22(e)	880,000(e)	--	880,000(e)	365,231	42(e)	365,231	15.01
NEW MEXICO										
Ambrosia Lake, Kermac Nuclear Fuels	11/58-12/70	13,230,218	0.21	55,862,937	455,383	56,318,320	54,803,959	97	43,302,213	7.49
Ambrosia Lake, Phillips Pet. Co.	6/58- 3/63	3,050,000	0.23	14,036,662	--	14,036,662	13,015,896	93	12,966,696	7.90
Bluewater, Anaconda Copper Min. Co.	10/53-12/70	10,032,560	0.24	48,590,085	--	48,590,085	45,014,024	93	39,649,637	8.88
Grants, Homestake New Mexico Partners	2/58- 4/62	1,241,774	0.22	5,567,850	--	5,567,850	4,996,753	90	4,996,753	8.45
Grants, Homestake Sapin Partners	7/58-12/70	11,608,206	0.20	45,646,845	627,694	46,274,539	43,059,934	93	37,255,671	7.88
Shiprock, Kerr-McGee Oil Ind., Inc.	11/54- 5/68	1,527,187	0.26	7,895,893	--	7,895,893	7,422,896	94	7,446,388	9.18
OREGON										
Lakeview, Lakeview Mining Co.	12/58-11/60	131,355	0.15	393,827	--	393,827	342,611	87	342,259	9.62
SOUTH DAKOTA										
Edgemont, Mines Development, Inc.	7/56-12/68	1,643,148	0.20	6,460,024	--	6,460,024	6,142,704	95	6,072,501	8.91
Edgemont, Mining Research Corp.[2]	Summer 1954	3,788	0.06	4,375	--	4,375	2,782	64	2,823	13.97
TEXAS										
Falls City, Susquehanna-West., Inc.	4/61-12/68	1,210,300	0.18	4,339,957	--	4,339,957	4,103,061	95	1,585,196	8.34
UTAH										
Hite, Vanadium Corp. of Am.	7/49-12/53	26,358	0.43	224,573	--	224,573	128,280	57	128,145	13.93
Mexican Hat, Texas-Zinc Min. Corp.	10/57- 2/65	2,199,480	0.28	12,176,707	--	12,176,707	11,384,427	93	11,384,427	8.86
Moab, Uranium Reduction Co.	10/56-12/70	6,354,733	0.34	43,762,217	--	43,762,217	42,031,597	96	38,500,282	8.07
Monticello, The Galigher Co.[3]	9/49- 1/60	903,298	0.31	5,548,694	--	5,548,694	4,583,028	83	4,583,028	9.92
Salt Lake City, Vitro Corp. of Am.	5/51- 1/64	1,688,577	0.32	10,701,519	--	10,701,519	9,573,883	90	9,574,499	10.80
WASHINGTON										
Ford, Dawn Mining Co.	8/57-12/66	1,171,315	0.24	5,560,134	--	5,560,134	5,314,770	96	5,279,675	9.03
WYOMING										
Gas Hills, Federal-Radorock-G.H.P.	10/59-12/70	2,676,315	0.17	9,703,477	--	9,703,477	8,942,190	92	6,469,895	7.92
Gas Hills, Globe Mining Co.	1/60-12/70	2,463,809	0.14	7,131,888	762,208	7,894,096	7,328,678	93	5,617,289	7.69
Gas Hills, Lucky Mc Uranium Corp.	2/58-12/70	3,484,556	0.31	21,500,217	1,675,992	23,176,209	21,912,119	95	16,748,202	7.76
Riverton, Fremont Minerals, Inc.	11/58- 5/63	909,203	0.20	3,697,685	--	3,697,685	3,400,454	92	3,891,237	8.51
Shirley Basin, Petrotomics Co.	4/62-12/66	786,928	0.24	3,778,418	28,778	3,807,196	3,672,925	96	3,583,821	8.00
Split Rock, Lost Creek Oil & U. Co.	4/57-12/70	4,004,282	0.23	18,541,002	436,692	18,977,694	17,720,644	93	14,935,569	8.11
Total AEC Purchases of U_3O_8									347,696,642	8.52 Average

Table B-4 - Uranium Mill Operations Under AEC Contracts and Other Uranium Processing Plants (continued)

Location & Initial Contractor	Operating Period	Ore Processed: Tons	Ore Processed: % U_3O_8	Ore Processed: U_3O_8 (Lbs.)	Other Feed U_3O_8 (Lbs.)	Total Millfeed U_3O_8 (Lbs.)	Production U_3O_8 (Lbs.)	Recovery %	U_3O_8 Purchased by AEC: Lbs.	U_3O_8 Purchased by AEC: Average Cost ($/Lb.)
OTHER URANIUM PROCESSING PLANTS*										
ARIZONA										
Monument Valley, Vanadium Corp. of Am.	1955-1967	1,100,000(e)	0.04 - 0.09(e)	Refer to report for estimated production						
COLORADO										
Slick Rock, North Continent Mines, Inc.	1931-1943	37,000(e)	0.28(e)	Refer to report for estimated production						
Slick Rock, Union Carbide Corp.	9/57-12/61	591,244	0.24	2,892,705	--	2,892,705	2,691,035	93	Production shipped to Rifle mill.	
NORTH DAKOTA										
Belfield, Union Carbide Corp.	7/65-11/67	47,614	0.37	364,966	--	364,966	338,393	93	Production shipped to Rifle mill.	
Bowman, Kermac Nuclear Fuels	3/64- 2/67	80,374	0.43	686,000	--	686,000	607,000	88	Production shipped to Amb. Lake mill.	
UTAH										
Green River, Union Carbide Corp.	3/58- 1/61	183,386	0.29	951,750	--	951,750	831,082	87	Production shipped to Rifle mill.	
White Canyon, COG Minerals Corp.	1957-1960	50,000	0.10-0.15(e)	Refer to report for estimated production and disposition.						
WYOMING										
Baggs, Shawano Development Corp.	1956-1957	15,000(e)	0.04-0.09(e)	19,500(e)	--	19,500(e)	Unknown	Unknown	1,000(e)	8.00(e)
Converse Co., Wyo. Mining & Milling Co.	4/62- 6/65	187,000	0.12	448,800	--	448,800	348,095	78	Production shipped to Split Rock mill.	

1/ Not a conventional mill - see Porter Bros. report, Appendix A.

2/ Pilot plant operation - not a mill.

3/ Only AEC-owned mill.

(e) = estimate, no actual data available.

* In addition to those plants listed here, the AEC had a pilot plant at its Grand Junction facilities that operated from March 1953 to June 1958, to develop and test new processes for use in uranium mills. During the course of its operation approximately 30,000 tons of ore from 40 different mines in the Western United States were tested. A total of 138,500 pounds U_3O_8 in concentrates was produced. After the plant was shut down in 1958 it was dismantled.

The pilot plant U_3O_8 production is not included in "U_3O_8 Purchases by the AEC" in this table or in Table B-3.